Developing a recommender mechanism for supporting mobile content reuse
ABSTRACT

Nowadays people got used to short text answers, likes and shares. Anyone can feel it by entering popular forums or social networks. Modern platforms such as Twitter or Facebook contribute to this situation with their symbols per message limitations. The quality of content produced in such conditions is not high. According to Knight and Burn (2005): “The rapid growth of the Internet and the lack of enforceable standards regarding the information it contains has led to numerous information quality problems.”

The possible solution to this problem is called mobile digital storytelling. It replaces traditional communication mechanisms (text, photos) with a digital narrative, thus making a stronger impact on user. Besides, it allows creating interesting content at any location with the help of mobile phone.

However, it is hard to make a high quality story from scratch without prior experience. Viewing through previously created high quality content provides such experience. At the same time, reusing this content would allow creating story by combining and rearranging instead of producing from scratch. But state of the art mobile digital storytelling applications don’t provide any possibilities for content reuse. In addition, the influence of content reuse on the story creation process was not studied.

Hence, in this work the researcher will explore and try to develop alternative ways to support content reuse in mobile digital storytelling (mDS). For this purpose a mechanism called RecSM (a recommendation system using content from Social Media) is introduced. The main goal of development is to create RecSM for mobile digital storytelling application. The influence of RecSM on mobile content reuse as well as the influence of reuse on storytelling process is the main study goals.

The thesis is based on research conducted in Linnaeus University, Sweden. The research is divided into two main parts: gathering requirements for RecSM and the case study. 10 users are involved in both activities. Initial requirements for RecSM are defined after conducting research in the topic but final requirements are determined with the help of users. Based on them the RecSM is developed and added to a mobile digital storytelling application. A case study in Teleborg Castle (Vaxjo, Sweden) follows afterwards. Participants create stories about their castle experience with the help of mDS or mDS-RecSM application. The data for further research is retrieved through field notes, personal interviews and a survey. Then stories and answers of people that used mDS with and without recommender are compared and analyzed. Based on the study outcomes it is concluded that developed RecSM supports content reuse in mobile digital storytelling.

Keywords: mobile digital storytelling (mDS), recommendation system, content reuse, RecSM, content creation and distribution, content movement cycle.
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1. INTRODUCTION

According to Anderson J. et al. (2011), 69% of Internet users in Europe are content consumers while only 23% are content creators. Hence, most Europeans navigating the Internet are not used to produce content on the World Wide Web. A good illustration of how people currently consume, create and share digital content was developed by Fangman M. (2012) and shown on Figure 1.

![Figure 1. How people interact with content on the Internet.](image)

Moreover, according to Findahl (2012), commenting, updating statuses and posting photos are the only popular Internet activities connected with content producing that are carried out by Swedish users aged 12-35 (Fig. 2). Listening to music, watching videos and playing games doesn’t bring any content. People that live in Sweden are the main target group for the current research and this is the main reason for showing the statistics presented below.

![Figure 2. Percentage of Swedish Internet users spending time on various online activities (Findahl O., 2012).](image)

Based on the same statistics, sharing took the place among less popular actions on the Internet in Sweden. Making posts on forums which is obviously a content creation process was also not very spread during 2012.

Statistics of Internet use in Sweden published at Nordicom (2013) shows similar results: the three most popular actions on the Internet among all users are reading online newspapers/news magazines (80% of users involved), listening to web radio/watching web television (63% of users involved) and playing/downloading games, images, films or music (56%).

The tendency of predominant content consumption in Sweden is obvious. This tendency has a possible influence on the Swedish Internet: the quality/quantity ratio of generated information become smaller, the helpful data is not always shared, it is harder to study things from different angles because people don’t provide their opinions, etc. A model suggested by Solis (2011) can be used to decrease the influence of predominant content consumption on the Internet by keeping the balance between creation, consumption, learning and sharing. The model is called “a successful content movement cycle” (Fig. 3):
Creating and sharing content are vital to keep the balance in this cycle. But as it was mentioned previously in the current work, these activities are not so popular compared to consumption among Internet users in Sweden. So how can we inspire people to produce and distribute content on the Internet? A recently developed approach called “Digital storytelling” that supports people in creating and sharing digital content (Lambert J., 2007, Nordmark S., Milrad M., 2012) can be utilized to sustain the content movement cycle and avoid the consequences of predominant content consumption. “A broad definition of a digital story is that it is a series of pictures with a voice-over and describing text” (Reitmaier T., Marsden G., 2009). Digital storytelling can provide users with novel ways to create and share digital content. Instead of plain picture uploading people will be able to tell their stories to the world. Potentially, it can improve communication on the Internet as well as increase the amount and quality of generated content by replacing short text messages with simple digital narratives.

To offer user more creativity space and allow creating stories anywhere and at any time digital storytelling was transferred to mobile devices. “Bringing digital storytelling to the mobile, while challenging, offers great opportunities. It would allow users without access to a personal computer to create and share their stories, thus giving them a digital voice” (Reitmaier T., Marsden G., 2009). During analysis of pre-recorded digital stories in “GeoStoryteller” application in 2013, Cacciolo A. & Rabina D. pointed out that mobile technologies give huge possibilities for users to create and share their own stories. According to Nordmark and Milrad (2012), mobile digital storytelling provides a possibility to combine creativity with collaboration and individual experiences, thus making a more powerful and individual impact on user then traditional communication mechanisms such as text messages or exchanging photos. As for technological background of bringing digital storytelling to mobile platforms, nowadays mobile technologies become more and more widespread. A quick acceptance of sensory smartphones and geo-location awareness caused almost an industrial breakthrough in the past few years. Findahl O. (2012) proved in his research that 54% of the Swedish population (aged 12 and up) frequently used mobile Internet in 2012. So today most of the people in Sweden have mobile devices constantly used across different contexts and settings.

The development of a new mobile digital storytelling (mDS) application began in November, 2011 at Linnaeus University (Sweden). “Mobile applications like StoryRobe, SonicPics, Blurb, etc. all have some areas where they lack functionality. The mDS app developed at Linnaeus University has the aim to improve these areas as well as to combine the good approaches from the existing applications” (Moltkau B., 2012). After being finished in 2013, the new mDS application fixed most of the issues connected with content production and distribution that were found by Moltkau in previously created storytelling applications. But mDS users were still restricted by surrounding conditions (for example, it’s very hard to create story at night or when it’s raining), ability to make good photos, creativity and few other factors. They were left alone in the process of story creation. For them there was no way to estimate ideas or content of other people that were in the same or similar conditions. Besides, it is usually hard to create a good narrative from scratch without prior experience in storytelling. Viewing through already created content may give such experience.

One of the possible ways to provide the functionality for viewing and estimating previously produced content is adding a recommender system. “Recommender systems help users to decide on appropriate items, and ease the task of finding preferred items in the collection” (Shani G. and Gunawardana A., 2011). Moreover, recommender system supports the reuse of previous experience by adding reviewed items into created story. It gives a possibility to create digital story by combining or remixing. This is easier than producing from scratch. The combination of recommender system with mobile digital storytelling application could become a powerful tool that supports content reuse and enhances mobile content creation.

Following the idea (Fig. 4) of Guy I. and Carmel D. (2011), the RecSM (recommender system using content from Social Media) mechanism is suggested in this Thesis. According to researchers’ thoughts, the innovative idea of combining mobile digital storytelling with RecSM would allow to reuse mobile content and to enhance...
content production and distribution on the Internet. Hence, within this work, the efforts are aimed at creating RecSM for an mDS application to support mobile content reuse. The aim of research part is to answer how RecSM may affect content reuse during digital story creation on mobile phone (see more details on research question in section 2.3).

Figure 4. How Social media and recommender systems benefit from each other (Guy I., Carmel D., 2011).

1.1 Motivation

The reason of working with mobile digital storytelling in the current study lays in its potential to increase content production and even to improve the way people communicate on the Internet. Digital narratives may become a very strong communication tool with a powerful impact on user. But studies in this field have a lot of gaps. For example, there is no way of reviewing or reusing previously created content while creating digital stories. Hence, for new users it is much harder to produce stories from scratch. A mechanism called recommender system could be a perfect solution in this case. Such system allows not only viewing through related content but inserting it into own narrative. Thus, recommender could help inexperienced users by showing examples of previously created content and at the same time become a way to support content reuse in mobile digital storytelling.

Based on the points presented above, the research efforts of this Thesis are directed into creating a recommender mechanism (RecSM) with a goal to support content reuse in mobile digital storytelling and analyzing its influence on the process of story creation.

1.2 Thesis Overview

This thesis is based development and research efforts conducted in Linnaeus University, Sweden. The author of the thesis suggests and develops RecSM mechanism and applies it to mobile digital storytelling with the goal to support mobile content reuse. A case study research is applied after adding RecSM to an mDS application. An analysis and evaluation of findings follows afterwards.

The thesis has the following structure:

- Chapter 1 provides basic introduction into the topic. The reader is explained the impact of predominant content consumption on the Internet in Sweden and shown a possible solution in form of successful content movement cycle (which can be implemented using mDS approach). The motivation for creating the thesis and thesis overview are presented after that.
- The analysis of previous solutions in the field of mobile digital storytelling and recommender systems is provided in Chapter 2. The research question statement and research sub questions to be studied are concluding the chapter.
- Chapter 3 explains the applied methodological approaches. It is divided into two subsections:
  - Research methodology that briefly describes phases of case study research to be conducted.
  - Development methodology that touches the prototype development.
- In chapter 4 the technical approach and implementation plan are illustrated in details. It starts with description of a previously developed mDS prototype followed by technical details of RecSM, recommendation sources and ways to improve recommendations. The chapter ends with a list of possible limitations in technical solution.
- The step-by-step case study research plan is describe in Chapter 5. Methods for data collection, participants, necessary materials, result analysis techniques and other parts of research to be conducted are shown in the according subsections of this chapter.
- Chapters 6-8 are devoted to practical part of the thesis. The results of user session for gathering requirements are shown in chapters 6. Then the actual implementation of mDS application with RecSM and its differences from planned technical solution are described in chapter 7. The outcomes of case study are presented in chapter 8.
Problem analysis and evaluation of findings are presented in chapter 9. The discussion touches different aspects of mobile digital storytelling and the influence of RecSM on these aspects. The concluding remarks for the whole Thesis as well as answer to the research question are presented in the end of this chapter.

Chapter 10 of thesis provides directions for further improvements.

Figure 5 illustrates the thesis structure described above:

![Figure 5. Disposition of the thesis](image-url)
2. RELATED WORK AND RESEARCH CHALLENGE

The state-of-the-art in digital storytelling and recommender systems is presented in the beginning of this section. It is followed by an overview of known mDS applications and applications with recommender systems. The research challenges and the main research question guiding the presented work conclude this section.

2.1 State-of-the-art overview

The process of digital storytelling was well studied and explained by Joe Lambert (2009, 2010) which is one of the founders of the “Center for Digital Storytelling”. According to Lambert, one of the main goals of this Center is to enhance ordinary users to produce digital stories about their life experience instead of watching through the previously generated content. Lundby (2008), Hartley and McWilliams (2009) and a number of other authors have shown that digital storytelling is already applied on practice to increase participants engagement and improve user interactions. If discussing the concrete implementations, digital storytelling is actively introduced to museum visitors. For example, Lombardo and Damiano (2012) changed stories based on the person’s route through exhibitions. Their solution is based on storytelling units which adapt a story to the current context. Callaway et al. (2012) developed a mechanism that selects different stories for different museum groups and then allows to virtually discuss the museum experience. However, in the described cases the museum visitor is rather a story consumer than creator, while the application itself acts as narrator.

In contrary to museum digital storytelling tools, scientific studies that focus on the story creation are mostly looking at applications for educating children of the school age. For example, Feher (2008) makes use of the strong pedagogical background to argue about the way digital stories can improve the learning curve. Cassell and Ryokai (2001) developed a StoryMat application for kids that uses surrounding real-world objects (in particular, animal toys) to augment the storytelling process. In StoryRoom (Alborzi et al., 2000), children are provided with whole physical storytelling rooms in which they experience different spectacles. Some authors, like Marshall et al. (2004), shift storytelling to virtual spaces where kids can produce digital stories together. Recently developed ShadowStory (Lu et al., 2011) provides all the necessary tools for children to make their own digital puppets acting as main characters in a story.

Though the number of available digital storytelling studies is decent, they mostly treat user as a story consumer. And even when this is not the case, the provided functionality for creating stories is often targeted at kids and is rather limited.

As for the state-of-the-art in recommender systems, most studies focus on synthesizing and optimizing the recommender algorithms that are responsible for suggesting appropriate content to users. For example, Knijnenburg et al. (2012) introduced RMFO approach that rates Twitter messages for every user and shows according suggestions. RMFO is based on collaborative filtering, i.e., recommendations depend on the previous user actions in Twitter (see details on filtering methods in Section “4.2 Recommender algorithm”). An extensive overview of papers that focus on recommender algorithms was developed by Burke (2002). The key point underlined by such papers is that more sophisticated algorithms provide more relevant suggestions which, in turn, improve user perception of the recommender and lead to successful interactions. However, a number of researchers (e.g., Konstan and Riedl, 2012) recently point on other parameters than the algorithm that affect user interactions with the recommender. Some of these parameters are described by a user-oriented framework for evaluating recommender systems that can be found in the work of Diaz-Aviles et al. (2012). This framework studies interconnection between the recommender parameters and user experience while, at the same time, takes into account personalities of participants and some contextual data.

Utilizing data from social networks has become one of the emerging topics in recommender systems. Ma et al. (2011) merge data from user social profile and item rankings to provide higher accuracy of recommendations based on matrix factorization and probabilistic theory. In Liu and Lee (2010), recommendations are based on user’s neighbors in the social graph. This study also compares the aforementioned approach with other known recommendation algorithms. As user perception of an item may be greatly influenced by circumstances, some authors began studying contextual social recommendations. Akther et al. (2012) creates highly personal recommendations based on data from social network and contextual information. The focus of this effort is shifted from the effectiveness of algorithms to extracting relevant data.

In contrast to existing works, RecSM is a new approach that combines digital storytelling with recommender system and, at the same time, uses data from social networks.

2.2 mDS applications review

As it was described in previous sections, digital storytelling may be a possible way to enhance content creation process. Simultaneously, mobile platform allows creating content at any situation and time, thus making stories
more diverse and contextual. Based on the combination of these two ideas, it was decided to look through different mobile digital storytelling (mDS) applications and check what functionality they offer in terms of a set of defined features. The comparison of seven existing mobile digital storytelling applications is shown in Table 1. The analyzed mDS applications are Voices of Oakland (Bolter J.D. et al., 2013), GeoStoryteller (Cocciolo A. & Rabina D., 2013), StoryBank (Frohlisch D. et al., 2009), MS Digital narratives (www.digitalnarratives.net), StoryRobe (storyrobe.com), SonicPics (www.sonicpics.com), StoryKit (Bonsignore, 2011).

These applications were chosen because they represent different topics, storytelling approaches and were created/studied by different researchers. These are definitely not all available solutions but they show the general tendencies.

The set of features (see first column of Table 1) was picked based on the need to analyze:

- Basic storytelling possibilities (add images, audio, subtitles, etc.). It was important to understand if all mDS applications provide the necessary functionality to create digital stories.
- Interesting non-standard possibilities (painting on images, zooming, adding video, geo-tracking, etc.). This was required to collect ideas from different mDS apps and implement best of them in the new solution.
- Content reuse possibilities (storing, sharing, tagging, recommendations). This was required by studied research problem.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Voices of Oakland</th>
<th>GeoStoryteller</th>
<th>StoryBank</th>
<th>MS Digital narratives</th>
<th>StoryRobe</th>
<th>SonicPics</th>
<th>StoryKit</th>
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</table>

Table 1. Comparing mDS applications

All analyzed applications include technical issues. For example, the interface of recording and especially re-recording audio is inconvenient: in most cases the voice has to be recorded in one take for the whole story. Hence, it’s hard to create a good story for a person that is not used to tell stories. In most applications there is no way to add a background soundtrack or video. Though some of the applications had interesting features such as zooming/moving image on a canvas, simple painting on images or augmented reality part, the important digital story functionalities such as adding subtitles or transitions are lacking. Besides, none of the applications took advantage of meta-data from generated content. They didn’t allow categorizing stories or any kind of tagging (except very limited possibility from StoryKit).

It appears that content creation process is problematic and limited in current mDS applications. But the most vital drawback of all mentioned services is that the majority of them don’t have a suitable sharing functionality. Thus, most analyzed applications don’t supporting the content movement cycle (Fig. 3). According to Bolter, Engberg and MacIntyre (2013): “One element that is becoming pervasive in all mobile applications is the desire to connect to Facebook, to Twitter or to image aggregation sites”. After conducted analysis it was found that only two of applications were able to create a video out of the story and allowed distributing it on the Internet.
Summing up the pros and cons of analyzed applications, the following features are expected from an mDS prototype to support content creation and distribution:

- Adding and rearranging images on a canvas so they form a sequence;
- Possibility to add subtitles and voiceover for every image;
- Audio recording interface with a pause ability (similar to mp3 player);
- Tagging stories or particular slides;
- Creating a single narrative (a video) out of the story and sharing it to some popular services;
- Few additional features that make stories unique with the help of visual or audio effects (adding a soundtrack, picking transitions, etc.).

Based on ideas of the current thesis (see “1. Introduction” section), it was decided to analyze same digital storytelling applications for the possibility to reuse already generated data in the created story. It appeared that alongside with problematical production and distribution of content, none of analyzed services provide possibilities for using any kind of previously created content. They don’t allow utilizing prior experience. Hence, the reuse of mobile content in digital storytelling applications is not currently possible. In “1.1 Motivation” section it was already mentioned that combining recommenders with digital storytelling may be an efficient solution to support content reuse and enhance content production on the Internet. But a careful study of recommendation systems is required before adding a recommender into mDS application. This study is described in the following section.

### 2.3 Recommendation systems review

Recommender is a system that filters displayed content with a goal to match user tastes in the best possible way. mDS applications review showed that there were no recommendation mechanisms in digital storytelling. Hence, it was decided to study known recommenders within the framework of other topics. A comparative review of existing services that include recommendation system is shown in Table 2. It includes Loopt (Adriana de Souza e Silva & Frith J, 2010), Libra (Mooney R. J. and Roy L., 1999), CHIP (Cramer H. et al., 2008), Amazon (Konstan J.A., Riedl J., 2010), Last.fm (www.last.fm) and NetFlix (www.netflix.com). These services were chosen as they represent different topics, filtering methods, algorithms and are known/popular on the Internet. The following set of features (see first column of table 2) was picked because it represents the main differences between existing recommender systems that are connected to current research topic.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Loopt</th>
<th>Libra</th>
<th>CHIP</th>
<th>Amazon</th>
<th>Last.fm</th>
<th>NetFlix</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is recommended</td>
<td>People</td>
<td>Books</td>
<td>Art</td>
<td>Books</td>
<td>Music</td>
<td>Movies</td>
</tr>
<tr>
<td>Number of recomm.</td>
<td>≈5</td>
<td>6-8</td>
<td>5</td>
<td>4</td>
<td>≈6</td>
<td>3-4</td>
</tr>
<tr>
<td>Filtering: 1-content, 2-collaborative, 3-both.</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Algorithm</td>
<td>-</td>
<td>Bayesian learning</td>
<td>Semantic annotations</td>
<td>Affinity analysis</td>
<td>Modified Slope One</td>
<td>Own machine learning</td>
</tr>
<tr>
<td>Recommends on mobile</td>
<td>+</td>
<td>-</td>
<td>partially</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Social media connection</td>
<td>Facebook, Twitter</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Facebook</td>
</tr>
<tr>
<td>Geo location</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2. Comparing recommender systems

Recommender systems normally make suggestions with the help of collaborative filtering, content-based filtering or a mix of these two methods (Shani G. et al., 2005) (Chen Li & Pearl Pu, 2011). The main point of collaborative filtering is matching preferences of different users. Usually, the system based on collaborative filtering contains profiles of all members which include all their rates, chosen products and personal information. The recommendation is based on the products that were chosen by other users that have similar preferences. Content-based filtering implies that recommendations on using similar content are given based on some characteristics of an item instead of relying on other peoples taste. (Mooney R. J. and Roy L., 1999). It means that user is recommended items similar to those that he examined previously or is reviewing in present. The filtering method depends on the goals of application. The reviewed services use different filtering methods. Loopt, for example, recommends all your friends that are near your current geographical location. Amazon, from the other hand, combines collaborative and content-based filtering.
The number of recommendations that are shown to a user simultaneously is also worth discussing. All analyzed services agree that it lies between 4 and 6. But these numbers are mostly applied to standard computers. Considering the small screen size of mobile phone, they should be divided by two. So 2-3 recommended items in mobile application should be optimal.

During recommendation systems review, a number of drawbacks were found in existing recommender systems. First of all, half of them don’t work on mobile platforms. Even famous Amazon which has mobile website version doesn’t recommend anything in it. Moreover, none of services except Loopt (which is by definition a location-based social network) gets use of geo-location data when filtering results. Taking into account the current location of user is very important and obviously makes predictions more accurate as people with similar tastes from the same region are more likely to buy the same product. Another disadvantage of reviewed recommenders is lacking connection to social media tools and platforms. Combining social media with recommender systems was proved by Guy I. and Carmel D. (2011) to be beneficial for both sides. Social media provides recommenders with new data sources that allow increasing the quality of suggested content. At the same time recommendations improve the relevance of content in social media (Fig. 4). Most of analyzed solutions, except Netflix and Loopt (which is based on Facebook by default), have no possibility of connecting to Facebook, Twitter or other popular social services. They don’t take into account profiles and tons of content generated in social networks. Hence, they lose all benefits described by Guy and Carmel.

Though modern applications with recommender systems are based on different algorithms and use various filtering methods, they have similar disadvantages. Most of them don’t work on mobile platforms, don’t take into account the geographical location of a user/item and can’t connect to social networks. Hence, when developing a recommender system for mDS application it was decided to utilize best practices from all analyzed solution as well as to add some new improvements.

2.4 Research question

The reviewed stand-alone storytelling applications (see section 2.2) as well as recommendation systems (see section 2.3) had numerous drawbacks. A combination of recommender system with mDS application was not found during research in the topic. Additionally, there were no studies on how RecSM may influence the process of mobile digital storytelling. In particular, it is interesting to understand whether recommendation system encourages the reuse of previously created content, hence increasing the total amount and diversity of generated content. For this reason, the main research question that guided the work presented in this thesis can be formulated as following: “How RecSM may affect content reuse while creating mobile digital stories?”

There are few ways how RecSM can affect content reuse. First, are users even interested in adding a recommendation to a story (hence, reusing) after seeing it in the interface? Second, does the indirect content reuse (e.g., getting ideas from looking through content and applying them to own story) take place during creation? Third, if there is an influence of recommender on content reuse than what are the consequences, i.e., are stories becoming bigger and more diverse? All these questions were planned to be studied in this work.

Moreover, previous content could be created in another mDS application or with totally different tools (for example, standard mobile camera application). In the current study both mentioned sources will be taken into account because it’s important to analyze the influence of all previous user experience on mobile content reuse.

The interesting additional research questions (addRQ) that will be addressed after completing the study are:

- addRQ 1. How much control over the actions does the user feel when using recommendations in mDS?
- addRQ 2. How RecSM influence the duration of digital story creation on mobile devices?
- addRQ 3. What is the dependency between using RecSM in mDS and intention to use the application again in future?

3. METHODOLOGICAL APPROACH

3.1 Research methodology

The methodology chosen for conducting the current research is called case study. Taking into account the nature of research question, it perfectly fits the current research: “in general, case studies are the preferred strategy when “how” or “why” questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context.” (Yin R.K., 2013). Besides, the advantages of this methodology (presented below) will allow deep studying of the problem and gathering lots of data to support claims.

The advantages of case study compared to other known research approaches (experiment, survey) are:
• In depth data can be gathered;
• The possibility to study multiple factors and their interaction;
• Studying rare cases of human behavior;
• Data from different people may be retrieved.

The disadvantages of case study are:

• Difficulties in generalization from single cases that can often be unique;
• Researcher can be biased or even miss some findings because of knowing the case too well before the start;
• Low confidentiality: even if participants names were hidden cases can be identified because of their unique characteristics;
• May consume a lot of time.

Most drawbacks of case study in current work will be almost eliminated because researcher will follow few simple rules to avoid unnecessary biases: questions will be generalized and will not contain hints on possible answer, the conversation will be recorded and analyzed separately, participants will not be pressured or guided when giving answers, etc. Besides, the researcher can stay neutral in most circumstances and have enough analytical skills to draw conclusions. Confidentiality is also not a problem as all participant groups will be completely anonymous for each other.

Case study will be implemented in 6 steps that were identified based on the works of Stake R.E. (1995), Simons H. (1980) and Yin R.K. (2013). These researchers produced a number of papers on how to make an efficient study as well as shared huge practical knowledge with the readers.

The list of successful case study steps based on their experience is presented below:

• Identify a research question (or questions);
• Pick a particular case (or cases);
• Choose methods for data collection;
• Prepare the environment;
• Gather the data;
• Assess and study received results.

The first step was already conducted in the current research (see section 2.3). The concrete implementation of other steps is discussed in “5. Design of the study” section.

3.2 Development methodology

A new mobile digital storytelling application is required to conduct the current study. But there are many software development methodologies and only one of them must be chosen to support the research needs. The Rapid application development (RAD) methodology was selected to implement the project. Gerber, Van der Merwe and Alberts (2007) describe it as follows:

“Rapid development methodologies shy away from rigor and formally prescribed processes. These methodologies acknowledge development phases, but generally move through these phases in an ad-hoc and incremental manner.”

RAD gives an opportunity to change the application functionality with the help of iterative approach. For example, if recommender algorithm needs upgrades after gathering requirements (see section 5.1), it can be done immediately. Besides, the application can be changed after quick and dirty test (see section 5.3) or after completing some steps of case study. Hence, development methodology supplements research methodology.

As for implementation background for the choice of RAD, all development methodologies try to control three main attributes: time, resources and functionality. Taking into account the limited time for creating Master Thesis as well as the fact that there is only one developer who is a researcher at the same time, RAD was a good choice to implement the project.

The advantages of RAD over other popular development methodologies (waterfall, scrum, etc.):

• Tools are aimed at minimizing the development time;
• Minimize product creation time by using ready-made modules, libraries or pieces of code;
• Each developer should be ready to perform multiple tasks. This decreases required human resources.
• The developer usually works in collaboration with scientists or other developers.

At the same time there are some drawbacks. RAD methodology:

• Is aimed for developing intermediate-level projects. Using this methodology for large and complex projects can lead to difficult situations;
Requires additional resources to reconcile the development process between developers and customers;
Will not be effective if developer is not interested in results or can’t work in collaboration;
Contains development phases when some quality parameters will be ignored in favor of flexibility. Moreover, RAD can’t be applied when requirements for the technical reliability are very high.

The disadvantages of RAD methodology should be discussed in relation to developed project:
• mDS prototype is not a large or complex project so it won’t cause issues or difficult situations;
• Discussion between developer and customers (thesis supervisor, users) is a part of Master Thesis so it won’t take extra resources;
• Developer is interested in achieving results because he wants to complete the Thesis;
• Requirements for the technical reliability of mDS prototype are not so strict. It means that few small bugs during case study research are acceptable.

It appears that RAD methodology perfectly fits the objectives of described project. It allows reducing the development time, using limited resources and matches research methodology. Thus, RAD was approved as a main development methodology.
4. TECHNICAL APPROACH AND IMPLEMENTATION PLAN

A previously developed mDS application that serves as a basis for implementing RecSM is described in the beginning of this section. The planned key steps for creating a recommender system are discussed in the following sections. These steps include gathering requirements (section 4.1), developing an algorithm (4.2), technical implementation (4.3) and setting additional recommender features such as sources (4.4) and quality improvement (4.5). The section ends with the list of limitations in the solution to be implemented.

Mobile Digital Storytelling (mDS) is an existing native iOS application. It was developed to support research needs in Linnaeus University, Sweden (Shevtsov S., Glynski D., 2012). The application included most of the features (mentioned in section “2.1 mDS applications review”) except tagging content production and distribution on the Internet. It allowed convenient creating digital stories on iOS devices and sharing them to YouTube or by e-mail.

An existing workflow for making a story in mDS is shown on Figure 6. Its simplicity is achieved by decomposing the process of creating a story into few easy steps. At each step user is provided with certain functionality which helps to complete a story. For example, on the first step user can name a story and on the second step - add photo to the story with the help of camera or by simply selecting a picture from the library. As it can be seen from the figure, user is directed through all steps from “Name story” to sharing at YouTube.

Figure 6. Story creation workflow in existing mDS application

mDS is constructed as a monolithic application created with XCode 4.2 and “Objective C” programming language. Besides, the technology of Automatic Reference Counting is utilized to reduce development time. The application uses few external libraries that are included through the source code and compiled together with the program:

- GMGridView (https://github.com/gmoledina/GMGridView) - a performant Grid-View for iOS. With the help of this component the slides are displayed on the screen in the form of flexible grid. The grid is able to adapt to any screen size.
- GPUImage (https://github.com/BradLarson/GPUImage) that applies GPU-accelerated filters and other effects to images, live camera video and movies. In comparison to Core Image (part of iOS 5.0), GPUImage allows to write own custom filters, supports deployment to iOS 4.0, and has a simpler interface. GPUImage is utilized to create transitions between slides.
- WEPopover (https://github.com/werner77/WEPopover) is an attempt to create a generalized version of the UIPopoverController which is only available for the iPad. In the developed application WEPopover was utilized to create context menus and modal windows for selecting photos.
- ESSVideoShare (https://github.com/eternalstorms/ESSVideoShare-for-OS-X-Lion). This framework provides convenient video uploading functionality for the following services: YouTube, Vimeo, Facebook, Flickr.

Only open and license-free formats are used to make the story data portable between different platforms. The whole story is placed in a single folder. It includes a lot of data (pictures, sound, etc.) that is structured with JSON (JavaScript object notation). Graphical data is stored in JPEG2000 format and audio data is compressed using CAF encoder. This allows exporting stories on almost any modern platform. The program is based on the storyboard technology (iOS developer library, 2013). It allowed using standard MVC model for iOS. The base controller for navigation is UINavigationController. The native iOS framework called “AV Foundation” is used for creating video.
As mentioned in “1. Introduction”, users were left alone while creating a narrative in all previous mDS applications. They got no hints on making good stories or a possibility to look through related material. RecSM is considered by researcher as a solution to this issue. Hence, the task of the current development is to build a new version of mDS that will include social recommendation system. The upgraded version is called mDS-RecSM (mobile digital storytelling with RecSM). However, the implementation of a new prototype can’t start at once. First researcher needs to gather and analyze requirements, then plan functionality and special features of a new application as well as develop the recommender algorithm. All these steps are described in the following sections.

4.1 Gathering requirements plan for RecSM

The process of gathering requirements can be described as determination of user needs in relation to some software system. This process rather emphasize on what is needed then on how to achieve it.

There are three main types of gathered requirements:

- Functional: indicate the task of the system;
- Data: show system structure and required data to be processed in future;
- Usability: set a suitable level of user satisfaction with the developed system.

In most cases there are few basic steps that are passed by researchers when determining requirements. They include finding and studying similar systems, evaluating needs of people that will utilize the developed system in future, sketching, creating a prototype, etc.

The requirements for existing mDS application were developed by Nordmark S. and Milrad M (2012) through a series of trials, research and analysis of the literature in the field. But requirements for an upgraded version mainly touch RecSM. Hence, they will be determined separately. Initial requirements for mDS-RecSM application will be received after a small research in the topic (see section “4.2 Recommender algorithm” for details). But final requirements will be determined with the help of users.

A user group that is planned to be utilized in the case study is described in “5. Design of the study. Step 2. Pick a particular case” section. The same people will help in determining requirements for the RecSM. Researcher will gather participants and give a small lecture about mDS, the art of creating digital stories and RecSM. After that participants will fulfill a survey that includes questions with predefined answers. The results of this survey can be found in section “6. Gathered requirements”. The initial requirements for mDS-RecSM will be updated based on them and presented in the end of section 6.

4.2 Recommender algorithm

Recommender algorithm is the most important part of RecSM. The algorithm that is planned to be utilized in mDS-RecSM application and its expected features are described in this section.

As shown in “2.3 Recommendation systems review” section, most analyzed recommender systems are based on either collaborative or content-based filtering. Collaborative filters work much better when there is a big amount of data about users, their tastes and community behavior. Data about concrete items or products is not so important in this case (Burke R., 2002, Chandrashekhar H., Bhasker B., 2011). Content-based filters, from the other hand, are very good in recommending new/unrated items and satisfy people with unique tastes. Information about other users and behavior patterns are not taken into account in that case (Cremonesi P., Turrin R., Airoldi F., 2011).

Both filtering methods were considered when planning a basis for recommender algorithm in the current project. The known problem of content-based filtering algorithm is a limited scope - it only suggests content that is similar to the current item (without taking into account the general tastes and preferences of user). But at the same time it needs very small amount of data to start working which is ideal in terms of current research and limited time. Besides, the developed mDS-RecSM application will not save any profile information and has no previous users so implementing collaborative filtering is not possible in it.

Implementation plan for the concrete content-based filtering algorithm on choosing related photos deserves a separate discussion. All previously analyzed recommenders (see Table 2) use either known mathematical algorithms (Bayesian learning, Affinity analysis) or develop their own mechanism. Most recommenders with content-based filtering rely on tags and standard item data (title, rating, date of creation, etc.) when calculating recommendations. It was proved by popular services to be an effective implementation so mDS-RecSM prototype will also rely on this data. However, according to researchers plan, developed recommender algorithm will compare geographical location of user and product on one of the first places. This should allow making more accurate predictions.

As mentioned above, the geo location will be the main parameter for selecting photos among thousands published on Flickr. Any modern mobile device is able to calculate its coordinates. The knowledge about picture
geo-location may be very useful in structuring photo collections, beginning from a big digital image library to a tiny private photo collection. (Toyama K., Logan R. and Roseway A., 2003). The locators usually have a mistake (approximately 10 meters). But the radius around current position from where the photos are selected will be set by user or 500 meters by default. The second important parameter of selection is story tags. Every created story in mDS-RecSM application will contain a special “tags” field in the “Name story” window. But even if some users won’t fulfill the tags, story name will be considered the main tag.

The combination of geo-location and story tags will be used to create recommendations in most cases. If there are no images from the current location with such story tags then recommender will ignore coordinates and create suggestions based only on tags. If the tags are too specific and Flickr is not able to show such photos then recommender will ask user to input tags again manually.

4.3 Recommender implementation plan

The concrete implementation of mDS-RecSM is described in section “7. Implementation of mDS-RecSM application”. The main idea of the recommender mechanism to be developed is as follows: based on geo and metadata from the created digital story, a user retrieves suggestions to use content from existing social media services (Flickr, in particular) that is similar to the story by topic, location and other parameters. In theory, the RecSM mechanism based on geo- and metadata should allow user creating more content by remixing new and existing. This will restore the balance in the successful content movement cycle (Fig. 3) and decrease the consequences of predominant content consumption (described in “1. Introduction”).

The implementation plan of RecSM is simple: after all metadata is gathered, mDS-RecSM applications send a query to Flickr (see dotted arrow from “Add images” to “Flickr” on fig. 7). More details about the query and the process of forming recommendations are discussed in section 4.4 and shown on Figure 8. Planned query parameters can be also seen on figure 9 (left part). In response to query the service provides recommended photos for a current story (see arrow from “Flickr” to “Add images” on fig. 7). They will be visible in the mDS-RecSM interface on the “Add images” window in form of sliding pictures. So user will be able to see the recommended photos before adding them. Only free images will be used in recommendations to obey copyright issues.

For people that are creating one story for many places (for example, a “day in Paris” story will probably include lots of sites) there will be a possibility to tag every picture. And after fulfilling the picture tags, user will be asked if he wants to see recommendations based on them. Let’s again look at “day in Paris” example to explain how it works. In this case story tags usually will be too generic: Paris, memorials, sightseeing, Eifel tower, Louvre, etc. But when user stands in the particular location such as Mona Lisa picture in Louvre, he inputs this name as a picture tag and will receive recommendations with images of Mona Lisa instead of generic pictures of Paris in some radius around.

The amount of times every image was added to favorites will be an additional parameter for sorting pictures in recommender. This is needed to make recommendations quality better and will be discussed in “4.5 Improving recommendations” section.

![Figure 7. Story creation workflow in developed mDS-RecSM application](image)

Figure 7. Story creation workflow in developed mDS-RecSM application

After completing the implementation researcher will conduct a simple quick and dirty test with one or two users to understand whether everything works as expected. This test is needed to check the prototype for critical bugs; minor issues are acceptable at this stage. More users are not required because detailed application study is a part of the main research. In case some functionality is lacking or some things are unclear to user, the immediate prototype changes will be made before conducting case study.

4.4 Recommendation sources

There will be two main sources of recommended content:
Generated through mDS-RecSM application on other devices. Basically, user will share all taken photos to Flickr before starting to create own story (shown by dotted line from “Name story” to “Flickr” on Fig. 7). These photos will be used in recommendations to other users that create similar stories. The question of privacy is very important in this case so user will be politely asked to share all taken pictures on the “Name story” screen. If a user doesn’t want to share anything then his pictures won’t be used in recommendations in future.

Created with other applications on any platform. These photos will be taken from Flickr directly. It means that if user shared photo on Flickr for public assess it will be used in recommendations.

After filtering based on recommender algorithm (described in “4.2 Recommender algorithm”) the content from both sources will be returned back to mDS-RecSM application in form of recommendations (Fig. 8).

4.5 Improving recommendations

An important part of the recommender system is that suggestions may improve after different devices generate similar queries to social services (e.g. when few people create story in the same location and input similar tags).

This will be implemented by putting pictures that are used in a story to users’ favorites in Flickr. Next user that makes similar query to Flickr will get recommendations that take into account the number of “likes” for every piece of content. As it can be seen from figure 9 (see page 19), users will get different sets of recommended photos in mDS #1, 2 and 3 after making similar queries to Flickr. We assume that the more people make similar queries the more accurate will be the recommendations.

4.6 Limitations

The first and obvious technical drawback of proposed solution is a mandatory Internet connection. But it is not a huge restriction because most people in Sweden (where research is held) have Internet connection.

The bigger restriction is that not all people specify the geo location of photo: on some devices this functionality is turned off, personal computer doesn’t have the necessary locating tools at all. That’s why at stage of planning it is decided to base recommender algorithm not only on location but on story tags, additions to favorites and other parameters.

Besides, user will be unable to add paid content to the story. This will create some restrictions on the quality of recommendations.

The final implementation limitation is that application functions only on iOS devices and interacts only with Flickr. Creating mDS versions for other devices and platforms could be a part of future work.
Figure 9. Improving recommendations (every action-arrow is numbered so they form a sequence)
5. DESIGN OF THE STUDY

Case study was chosen as the main research methodology in the current work. As described in the “3.1 Research methodology” section, it could be implemented in 6 steps. The implementation plan for every step is presented below:

Step 1. Identify a research question

This step was already finished in the current study and described previously (see section “2.3 Research question”).

Step 2. Pick a particular case

The domain of tourism was chosen to conduct a study and determine the influence of RecSM on content reuse in mobile digital storytelling.

The plan for studying the case is as follows: participants are gathered in campus of Linnaeus University, Sweden. They have an excursion through Teleborg Castle situated near university buildings and visit its most interesting parts. The excursion is conducted by the researcher himself. All participants have devices with preinstalled application. Half of them own old mDS version (without recommender) and the other half have mDS-RecSM version. The task is to listen to the lecture about interesting places of Teleborg Castle and make photos. After the end of lecture, participants are gathered in a classroom and have some time to create digital stories with the help of mDS/mDS-RecSM application. In marketing research the described above procedure is called the A/B test. It implies existence of two groups: experimental (with some specific conditions) and control (no specific conditions). See figure 10 for details:

![Figure 10. General A/B test scheme (Kohavi R. et al., 2009)](image)

In the current research it was decided to focus efforts on one particular user group - informants in the range of 20-30 years old of age. This people are familiar users of technology and potentially are the main user category for the application to be developed.

As for concrete sample group in this case, students from Social media and Web Technologies and some other student from Linnaeus University campus were selected. They are of different age, sex and nationality. The plan was to utilize 7-10 people in this study.

Step 3. Choose methods for data collection

Few sources of data collection were chosen to conduct the research:

- Direct observation will be applied as main data gathering instrument during the process of story creation. Multiple types of data could be collected within observation. They include photo, video, notes, audio recording, etc. In the current case field notes will be taken to record observation results. It means that there will be no predefined report structure and everything will be noted in a form of narrative. This is a qualitative research method. It implies direct interactions between participants and researcher. “What is important about well-collected qualitative data? One major feature is that they focus on natural occurring, ordinary events in natural settings, so that we have a strong handle on what “real life” is like”. (Matthew B. Miles, Huberman M., 1994) The main goal of researcher during observation is to study users’ point of view.
• Personal open-ended interviews will be the main instruments for gathering opinions. This is a qualitative research method. The impact of RecSM on reusing content and thus making the creation process easier will be studied here. Interviews will be guided with a check-list to sustain structure and consistency. Gathered data on this step will include facts, estimations and unpredicted personal thoughts. Field notes will be again taken to record information.

• Participants will take part in a distant anonymous survey. Usually in a survey all answers and questions are predefined. Participant just picks one of the answers without telling thoughts or discussing a problem. In the current study all users will receive a questionnaire by e-mail and fill it out in a calm home atmosphere. This will allow some people to grasp and better summarize their experience. Besides, some of participants may be shy or doesn’t want to hurt feelings of researchers by straight answers in the interview. Anonymous survey is a chance to see what people truly think of the system and its impact.

**Step 4. Prepare the environment**

Each participant will be contacted and asked for cooperation before the case study. The basic information about the ongoing research will be explained in case of positive response. Then all participants will be gathered on a short practice session and tough to create simple digital stories. Besides they will see the basic functionality of mDS application and try making a sample story with few slides.

The main material in the research is the upgraded version of mDS application (mDS-RecSM). The participants will receive iPods v.4 with iOS 6.1 and pre-installed application. No other services except standard will be installed on devices to prevent external impact on the study or crashes caused by interactions between applications.

Bidwell N. J. & Reitmaier T. et al. (2010) suggested that when nothing distract user from creating a complete story in a step by step mode, it supports people that make stories by collating, people that made photos in difficult conditions and couldn’t arrange them previously or people that lacked the general story plot. That’s why participants will create stories in a closed isolated classroom.

Moreover, both the excursion and practice session will be conducted indoors because Coccio & Rabina (2013) proved in their study of digital storytelling application with more than 30 users that “user engagement is significantly affected by weather and temperature… it can negatively impact user reports of their learning experience”. Hence, weather won’t affect the research when conducting it inside the building.

After the practice session every participant will be asked to make an appointment for individual interview and promise fulfilling the post-study survey.

Another thing to prepare is the excursion through the Teleborg Castle. Some local workers will be asked to help in creating interesting stories about different objects and places of the building. The stories will be structured and combined in a single lecture with pre-assigned points of interest.

**Step 5. Gather the data**

The process of gathering data will start even during the tour around Teleborg Castle. Field notes will help researcher to approximately evaluate the attention and involvement level of people during this excursion. Then, researcher will observe and record the behavior of participants during story creation process. As it is hard to record notes about many people at the same time, researcher will divide participants into pairs. Benyon also gives a good reason for splitting people into small groups: “this tends to elicit a more naturalistic flow of comment, and people will often encourage each other to try interactions that they might not have thought of in isolation” (2010).

One person from the pair will use recommender and another will create story without it. After both people from the pair finish their story, they will leave the room. Researcher will invite next pair and continue observation.

Researcher will take into account the following criteria when writing filed notes:

- interactions with recommender system:
  - convenience of recommender;
  - complexity of recommender system for new users;
  - amount of good and bad features mentioned by users;
  - cases when user is losing control of the recommender system;
  - other unexpected interactions.
- how often users are distracted from story creation;
- general impression:
  - satisfaction towards the application interface;
  - possible conversation between participants;
  - reaction on events happening during story creation;
  - amount of passed workflow steps;
• etc.
• frequency of help and documentation use;
• amount of help required outside of application;
• fails:
  • number of application failures ;
  • time spent in errors;
  • amount of times when interface mislead a user.
• other.

For some parameters it will be convenient to use the program interface which records data about stories. These parameters include: story length, number of taken pictures, number of used pictures, number of shared pictures and number of user recommendations.

Due to particular technological problems logs are not applicable for the following criteria (they will be measured with filed notes):

• number of errors - during errors the application often shuts down completely without recording anything in a log;
• time in errors - timer doesn’t work when application shuts down;
• frequency of help and documentation use - documentation is visible on the screen all the time. Hence user doesn’t press anything to unveil the help screen and nothing can be recorded in a log.

The written notes also will be made during personal interviews. The structure of dialog will be connected with research question and sub questions that were defined previously. For example (Table 3):

<table>
<thead>
<tr>
<th>Research question</th>
<th>Interview questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main research question. How RecSM may affect content reuse while creating mobile digital stories?</td>
<td>Did you use suggested content in your story? Were the recommendations helpful?</td>
</tr>
<tr>
<td>addRQ 1. How much control over the actions does the user feel when using recommendations in mDS?</td>
<td>Did you feel that the application encouraged you to create content?</td>
</tr>
<tr>
<td>addRQ 2. How RecSM influence the duration of digital story creation on mobile devices?</td>
<td>Do you think recommender system was intrusive? Were recommendations contradictive with your own choices?</td>
</tr>
<tr>
<td>addRQ 3. What is the dependency between using RecSM in mDS and intention to use the application again in future?</td>
<td>Did you feel that recommendation accelerated the process of story creation?</td>
</tr>
<tr>
<td></td>
<td>Would you agree to repeat the experience of creating digital story with recommendations?</td>
</tr>
</tbody>
</table>

**Table 3. Dependency between research questions and interview questions**

The final part of gathering data is a survey. It will contain question on both the effectiveness of RecSM system and its impact on story creation process. Chen Li & Pearl Pu (2011) suggested a number of sample questions to evaluate recommender systems by different criteria (see Table 4). Some of them will be utilized to evaluate mDS-RecSM application and answer research question. Additional questions will be created by researcher for deeper analysis of recommender and its impact on digital storytelling.

The written survey will be e-mailed to all participants with a set return date. After receiving responds data from survey will be saved locally in simple txt file for further analysis.

<table>
<thead>
<tr>
<th>Measured variable</th>
<th>Question responded on a 5-point Likert scale from “strongly disagree” to “strongly agree”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective perceptions of system-design features</td>
<td></td>
</tr>
<tr>
<td>Transparency</td>
<td>I understand why the products were returned through the explanations in the interface.</td>
</tr>
<tr>
<td>Recommendation quality</td>
<td>This interface gave me some really good recommendations.</td>
</tr>
<tr>
<td>User control</td>
<td>I felt in control of specifying and changing my preferences in this interface.</td>
</tr>
<tr>
<td>Overall competence perceptions</td>
<td></td>
</tr>
<tr>
<td>Perceived ease of use</td>
<td>I find this interface easy to use.</td>
</tr>
<tr>
<td>Perceived usefulness</td>
<td>This interface is competent to help me effectively find products I really like.</td>
</tr>
<tr>
<td></td>
<td>I find this interface is useful to improve my “shopping” performance.</td>
</tr>
</tbody>
</table>
Table 4. Evaluation framework for recommendation systems (Chen Li & Pearl Pu, 2011)

**Table 4. Evaluation framework for recommendation systems (Chen Li & Pearl Pu, 2011)**

**Step 6. Assess and study received results**

The evaluation of findings consists of two main components: the objective measures and subjective measures. The data about first component is gathered with filed notes and direct observation. The subjective measures (perception, trust, etc.) are studied with the help of interview and survey where users will tell their subjective comments and thoughts after finishing the story creation.

Within-case analysis technique will be used to assess received information. Interview questions and answers will be categorized and evaluated for connections and distinctions within the group of all participants. Survey response data from every participant will be studied separately to recognize unique features. Then received tendencies will be combined with field notes to make a final conclusion about the results of study and to give answer to the research question.
6. REQUIREMENTS GATHERED FOR RECSM

In general, the practical study was divided into two parts. According to plan (see section 4.1) the first part is needed to gather requirements for RecSM. The current section introduces participants and their answers on a gathering requirements survey. The survey consists of questions in 3 categories: general impression on recommendations (section 6.2), selection criteria for recommendations (section 6.3) and recommender interface (section 6.4). The analysis of answers and deriving requirements for the recommender to be developed are concluding section 6. The development of mDS-RecSM application starts afterwards (see section 7).

6.1 Participants and the setting

A sample group of ten participants fulfilled the gathering requirements survey. All of them are citizens of Ukraine and study in Linnaeus University, Sweden. Researcher decided to choose people of the same nationality as himself to make research process easier and remove possible language difficulties.

Users’ personal features are as follows:

- Sex: man(6), woman(4);
- Age: 22(4), 23(2), 24(3), 27(1);
- Study program: Information systems(3), Applied mathematics(2), Software technology(2), Electrical Engineering(1), Social Media and Web Technologies(2).

As it can be seen, the number of men and women among participants is almost the same. Most of them are between 22 and 24 years old – it is a typical age for students. Study programs of users differ but all of them are familiar with mobile technologies, social services and the Internet in general.

It’s important to note that users were not invited in a classroom as it was planned previously (see subsection “4.1 Gathering requirements plan for RecSM”). Instead, they were given an online survey. The survey started with a short textual introduction to digital storytelling and RecSMs. The prototype was not shown on this stage. Revealing such a little volume of information was done with a goal to make user actively think in any direction and provide as many ideas as possible.

6.2 General impression on recommendations

This section of survey contained six questions. They touch general thoughts of users on recommender systems, types and sources of recommendations, privacy. The answers and discussion about every question is shown below.

**Question 1.1.** I would be interested to see and/or use similar content from social services when creating a digital story. Answers are shown on figure 12.

General tendency is very clear from the figure: 7 out of 10 users are hesitating about their answer. Probably, they never faced recommendations in digital storytelling and it’s hard for them to imagine pros and cons of such system. From the other hand, answers on question 1 show that the concept of RecSM in digital storytelling is not rejected by people.

![Figure 12. Requirements survey results for question 1.1.](image)

**Question 1.2.** I would be interested to see and/or use similar content created by other users in the same mobile application when creating own digital story. Answers are shown on figure 13.

Again, most of users are hesitating about the answer. Although this time there is one completely negative answer, the conclusion is the same as in question 1.1: the concept of recommending content from the same application received neutral feedback and can be implemented without losing potential buyers.
**Question 1.3.** If photos taken by me were used as recommendations for other users then I… Answers are shown on figure 14.

The question of privacy in recommenders is really important and was described by Shyong K. Lam et al.: “The personal information collected by recommenders raises the risk of unwanted exposure of that information. Also, malicious users can bias or sabotage the recommendations that are provided to other users.” (2006)

Hence, users were asked about the possibility of showing their photos to other people. 80% of participants were not against sharing pictures. But in the developed solution every potential user is important. It’s not affordable to lose 20% of customers because of a privacy issue. The solution was found with the help of participants. One of them added own thoughts to this section of survey. He suggested the following: “I have a comment on the use of my content in recommendations to other users. Generally, I wouldn’t mind if someone does that. But there can be some private photos which I wouldn’t like to show. In other words, let the user choose what to share.”

**Question 1.4.** I would like to receive the following types of media in the form of recommendations when creating a digital story (multiple choice is possible). Answers are shown on figure 15.

90% of users confirmed the choice of main media source used in recommendations in the developed application. As for other types of recommendations (music, video, sound), they could be implemented in future versions of mDS-RecSM applications.

**Question 1.5.** Name the social services from which you would like to receive the recommended content. Answers are shown on figure 16.

This question didn’t have predefined answers. Every participant was obligated to write the names of services by himself. Important information was received here. It appears that most users prefer popular social networks (Facebook and VKontakte - Russian analogue for Facebook) instead of well known standalone image-sharing or video-sharing services.
Question 1.6. I think that the recommendations would help me to… (multiple choice is possible). Answers are shown on figure 17.

Question 1.6 was a sort of transition between sections of the survey. It touches both general impressions and selection criteria for recommendations. Most users indicate that they need suggestions because they want to add new details to their story. 40% also tell that they want to replace their poor quality content with professional photos. It means that in recommendations users require pictures similar to their own.

Besides, answers show that people don’t want to change their story completely based on recommendations or look at things from a different angle. Before creating a story they form a plot in their mind and stick to it. Hence, there is no need in very dissimilar recommendations to help user make up a story.

6.3 Selection criteria for recommendations

This section of the survey contained four questions. They mainly touch sorting and filtering methods for recommendations. The answers and discussion about every question are shown below.

Question 2.1. I would like to see the following content in recommendations. Answers are shown on figure 18.

The tendency from previous subsection of survey (Fig. 17) was again proven in question 2.1. People want to see in recommendations either very similar content or slightly different from what they create.

Question 2.2. I would like to receive the recommended content based on the following parameters (multiple choice is possible). Answers are shown on figure 19.

It’s important to point out that the novel idea of combining geo location with RecSM in mobile digital storytelling was supported by 70% of users. As it can be seen from Figure 19, most participants would like to receive suggestions that are not based on standard filtering methods (collaborative or content-based) but on their current physical location. As for chiose of standard filtering method, users prefered content-based filtering represented by answers 2 and 3.
Question 2.3. I would like to sort the items that match parameters from question 2.2 by… Answers are shown on figure 20.

In question 3 users were asked to select a sorting criterion for similar content in recommender. Opinions divided between all options. A possible solution was suggested by one of participants. The same user that already gave an idea in previous sections of survey wrote: “Again, I suggest giving user an opportunity to choose sorting criteria.”

Figure 20. Requirements survey results for question 2.3.

Question 2.4. If recommendations are taken from the Internet then the most important for me is… Answers are shown on figure 21.

This question showed that most participants want to view qualitative content even if it loads slower and takes more Internet traffic.

Figure 21. Requirements survey results for question 2.4.

6.4 Recommender interface

This section of survey contained three questions about recommender interface. The answers and discussion about every question is shown below.

Question 3.1. In what part of the mDS application interface you would like to see recommendations? (multiple choice is possible). Answers are shown on figure 22a.

Question 3.2. What portion of the phone's screen would you allocate for the recommender? Answers are shown on figure 22b.

Obviously it was hard for users to talk about interface of recommender without seeing the actual application. Nevertheless, half of them chose the same position (at bottom) and size (1/5 of screen).
Question 3.3. How many recommendations would you like to see on a screen simultaneously? Answers are shown on figure 23.

This particular question was very important for researcher. Before conducting a survey there was no clear answer on how many pieces of recommended content should be visible on the screen. 90% of participant emphasized that this number lays between 1 and 4.

6.5 Analysis of received answers

Both question 1.1 and 1.2 were needed to understand first thoughts of users when meeting a developed concept and measure the acceptance of the system. The mDS application doesn’t need any changes under the influence of received answers. Question 1.3 showed that the mDS application should be rebuilt in such a way that it allows user to select photos for sharing. In case user is against distributing pictures on the Internet, such modification will obey his privacy. Answers on question 1.4 confirmed researchers’ choice of media type for the application so it didn’t affect the prototype.

In spite of this tendency received in question 1.5, it was decided to keep Flickr as a main source for recommendations. There are a couple of reasons behind that:

- Flickr has enough photos and possibilities to prove or disprove a concept. It is unnecessary to use more popular social network in current research;
- The application was technically more prepared to work with Flickr API. Connecting Facebook API would require lots of effort from researcher;
- Participants are Ukrainians. Global services like Flickr and Instagram are rarely used in this country. VKontakte social network appears in results because of the same reason.

Hence, the developed recommender was not changed in any way because of answers on question 1.5. At the same time, it would be good to implement connection of mDS applications with other popular social networks or services in future.

Based on answers in questions 1.6 and 2.1 the algorithms of finding recommendations in mDS-RecSM application must be developed in such a way that they provide mostly similar content in suggestions. According to answers on question 2.4, the recommender must be settled to provide best possible quality of any photo that matches its algorithms.

In general, question 2.2 proved the choice of filtering methods in the developed solution so the algorithms of finding similar content should be based on geo-location and matching tags. At the same time users couldn’t come to a single answer in question 2.3. It was decided not to implement the solution suggested by a participant (to give user a possibility to tune up algorithms) because it would ruin the simplicity of interface and require a separate screen with recommender options. Instead, different sorting algorithms were applied to different
methods of finding similar content. As a result, the number of algorithms in the developed mDS-RecSM application increased from two (tag-based and locations-based) to six:

- Tag-based with sorting by relevance (accuracy of matching);
- Tag-based with sorting by popularity (number of “likes”);
- Tag-based with sorting by date (creation date);
- Locations-based with sorting by relevance (accuracy of matching);
- Locations-based with sorting by popularity (number of “likes”);
- Locations-based with sorting by date (creation date).

The mDS-RecSM application interface would be based on the most popular answers in question 3.1 and 3.2: the recommender will be situated at bottom and take 1/5 of phones screen. As opinions on amount of displayed recommendations in question 3.3 divided, it was decided to take an average solution: show three recommendations in horizontal layout and two in vertical layout.

6.6 Summing up prototype changes
The following changes in the mDS prototype were required after analyzing received answers:

- Allow user to select photos for sharing;
- Add recommender that provides best possible quality photos;
- Increase the number of recommender algorithms from two to six;
- Tune up algorithms so they provide similar content in suggestions.
- Display 3 recommendations simultaneously on a mobile phone screen.
7. IMPLEMENTATION OF THE MDS-RECSM APPLICATION

Existing digital storytelling application developed previously in Linnaeus University and described in “4. Technical approach and implementation plan” section became a basis for mDS-RecSM prototype. Both applications use storyboard technology, same external libraries and license-free formats. But the technical part has undergone little changes. First of all, mDS-RecSM application includes a couple more libraries:

- AGImagePickerController (https://github.com/arturgrigor/AGImagePickerController). It is an image picker controller that allows selecting multiple photos and can be used for all iOS devices.
- ObjectiveFlickr (https://github.com/lukhnos/objectiveflickr) - Flickr API framework designed for Mac and iPhone apps. It allows making request to Flickr and processing responses in a convenient way.

Besides, the changes to mDS that were needed after gathering requirements were implemented:

- Added possibility to select photos for sharing. The images are picked with AGImagePickerController;
- Added a recommender mechanism that is based on six algorithms. When researcher started to implement all the algorithms, he faced unexpected results. For example, some popular items that appeared after tag-based search were completely irrelevant. Sorting by creation date was not as good as sorting by posting date. Besides, some algorithms showed very similar results. So the final implementation of algorithms is described separately in “7.1 Recommender algorithms” section;
- Recommender provides mostly similar and high quality content. The level of similarity for retrieved content are set in the request to Flick API by tag_mode (for tags) and accuracy (for location) parameters. The quality of received photo can be set after Flickr returns a response with a list of matching pictures. It is set to “original” (which means the best possible) by default so researcher didn’t make changes here. A possibility of trading quality for loading time was also considered. If photos load more than a minute then it will cause confusion or incomprehension for some users. So researcher checked the loading time of recommender for different amount of recommended photos with the best possible quality. The results were sufficient: loading took not more than 30 seconds for 25 best quality photos. Hence, the quality of provided recommendations remained on a highest level;
- The overall interface changed in such a way that it shows two (vertical position) or three (horizontal position) recommendations on a mobile screen. This was implemented with standard storyboard elements.

Finally, most of the new mDS-RecSM features were implemented according to the initial plan (suggested in “4. Technical approach and implementation plan” section):

- Added functionality for tagging a story with the help of a simple text field (fig. 24 - left);
- Added the possibility of sharing selected photos to Flickr for further use in recommendations to other people (fig. 24). The story parameters (name, tags, etc.) are placed in according parameters of the shared photo. Photos are shared with the help of a POST request. Full procedure is described in API documentation (https://www.flickr.com/services/api/upload.api.html);
- Added recommender interface with sliding pictures (fig. 25). Hence, the general workflow changed from figure 6 to figure 7;
- Prototype uses two main sources of recommended content: generated through mDS-RecSM application on other devices and created with other applications on any platform (see section “4.4 Recommendation sources” or Fig. 8 for details). This was implemented by placing appropriate tags and geo information into photo parameters when sharing it to Flickr from mDS-RecSM;
- Recommended photos used in a created story are added to user favorites on Flickr. This potentially allows improving recommendations after similar requests (see section “4.5 Improving recommendations” or Fig. 9 for details). This was implemented with flickr.favorites.add API function (https://www.flickr.com/services/api/flickr.favorites.add.html).
7.1 Recommender algorithms

According to plan (see “4.2 Recommender algorithm”), recommendations in mDS-RecSM application should have been based on a combination of geo-location and story tags. During gathering requirements users proved their interest in this concept (see “6.3 Selection criteria for recommendations” section for details). User opinions divided when the process reached a point with determining sorting criterion for recommendations. Hence, it was decided to increase the number of algorithms up to six by combining different sorting and filtering methods. As it was mentioned in the beginning of section 7, the researcher faced difficulties when he started implementation of these algorithms in mDS-RecSM application: some of methods showed the same recommendations, some of them suggested completely irrelevant pictures, some sorting criteria were not accurate, etc.

Moreover, according to plan described in “4.5 Improving recommendations” section, the amount of additions to favorites should be taken into account in every algorithm. Practice showed that in many cases picture with a biggest number of “likes” are not the best choice for recommendations in storytelling. For example, in the location of Teleborg Castle where researcher conducted a study, the most “liked” pictures contained a beautiful motorcycle in front of a castle. The tags of these pictures were irrelevant but it was “liked” much more than other photos. Hence, the picture with motorcycle appeared on the first place in almost every algorithm that took into account the amount of additions to favorites.
After a series of fixes, tests of Flickr search/sorting methods and a tune-up, researcher got a final list of algorithms that were used in the implementation and provided varying and quite relevant results. Two of them are tag-based, two are geo location-based and one is based on both location and tags:

- #1. Search for story tags in tags of photos. Sort by relevance (accuracy of matching). This is the first tag-based algorithm from the planned list (see “Selection criteria for recommendations” for details). Relevance is counted by Flickr based on own protected algorithms similar to Google's order by relevance. The only thing that researcher influences is a search query. In this algorithm the story tags are used in a query.

- #2. Search for story name in picture title, description and tags of photos. Sort by relevance. This tag-based algorithm was added by researcher. It appeared that not every person wants to write tags. Also not every person understands how to properly tag content. Hence, researcher decided to use story name in a search query with the same sorting parameters.

- #3. Search in current geo location for photos containing first word from story tags in photo title, description or tags. Sort by relevance. Radius = 500m. This geo-based algorithm also came from the planned list. At the same time it was a bit transformed. Instead of plane geo-based query this algorithms takes first word from story tags and searches for it in current location. As a result, received algorithm combines tag- and geo-based queries. Sorting is again based on relevance.

- #4. Search in current geo location for photos uploaded before 2013-05-30 (scheduled date of first experiment in the castle). Sort by date posted. Radius = 500m. This algorithm is also very close to the plan. But plain geo-based algorithms provided very similar recommendations during first tests (without users). So it was decided to add a new parameter for them. In this algorithm only photos that were uploaded before case study in the Castle were taken into account. The sorting criterion is “posting date”.

- #5. Search in current geo location for photos uploaded after 2000-01-01. Sort by interestingness (number of “likes” + other criteria). Radius = 500m. This algorithm was modified few times compared to planned version. First, researcher had to add posting date in the algorithm to diversify geo-based recommendations (the same problem is described in previous algorithm). Then “amount of likes” was replaced with Flickr's own parameter called “interestingness”. This was done because new photos have no chance to appear in results if taking into account only amount of likes. From the other hand, interestingness is a complex parameter that gives a chance to every photo. Flickr developers (20???) define it as follows: “There are lots of elements that make something 'interesting' (or not) on Flickr. Where the clickthroughs are coming from; who comments on it and when; who marks it as a favorite; its tags and many more things which are constantly changing.”

- As for tag-based algorithms with sorting by popularity or by creation date, they showed totally irrelevant results and were removed from the list.

The Flickr API method used for implementation of all algorithms is called `flickr.photos.search` (https://www.flickr.com/services/api/flickr.photos.search.html). It takes all sorting and filtering parameters in a query and gives a list of matching photos in response. In the current implementation the most used parameters of search were tags (to search only in picture tags), text (to search in titles, descriptions and tags), sort (sorting order), lat and lon (geo location). All queries were created and processed with ObjectiveFlickr framework for simplicity.

Three important side notes must be mentioned:

- If user didn’t specify tags then application uses story name instead. This allows all five algorithms to work properly independent of user will in creating tags.

- Four photos from every algorithm are taken per time. It means that 20 photos are loaded in recommender at once before user starts working with it. Photos from every algorithm are taken successively so every photo has approximately equal chances of being chosen. To make it clearer let’s demonstrate the sequence of photos in recommender taken from every algorithm (numbered from 1 to 5):

  1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5

- After some discussion it was agreed to add logging functionality. Logging is a type of indirect observation. Its idea is to register all user actions in a separate “log” file and then examine it. Logging shows what exactly was done by user and can be an effective way to receive data.

  In the current application logging is implemented on a primitive level. Logs only track pictures that user choose from recommender. It helps to define the most popular algorithm for selecting recommended photos. It allows comparing what users wanted to see in recommendations with what they actually pick during tests.

An example of recommendations in mDS-RecSM prototype for a story about furniture of Teleborg Castle that was created in Linnaeus University campus (approx. 500 meters from the castle) is shown on figure 26.
All recommendations were manually numbered to simplify explanations that are shown below.

As it can be seen from the figure 26, photo 1 and 2 were taken in the castle and represent some furniture. These photos were received with tag-based algorithms. Photos fit the story plot nicely because story name and tags include words “Teleborg” and “furniture”. Photo 3 also recommends some furniture. But creator is located in campus so the nearest geo-tagged picture connected to furniture is shown as recommended. This is a photo from some apartment. If creator was making story in the castle then picture would be totally different. Photo 4 is provided by geo-based algorithm that sorts pictures by posted date. Hence, we can see the nearest to creator photo that was uploaded recently. It is a photo of cake with “VAXT” sign. VAXT is a student organization that functions in campus. The motorcycle mentioned previously in this section is visible on photo 5. This happens because algorithm 5 is based on “interestingness” (amount of additions to favorites). Most Flickr users think that this picture is the best you can see in the entire campus area. As a result, it’s provided in recommendation, though it is not really connected with furniture in the castle. Photo 6 is based on the same algorithm as photo 1 so castle furniture is again visible on it.

7.2 Unrealized implementation plans

At this stage it was decided not to implement other planned functionality such as:

- Possibility to tag every picture. This feature would complicate the interface. Also, implementation requires much effort from developer;
- Recommender options. Already on “Gathering requirements” stage it was clear that there are too few options that should be adjusted by user. Moreover, adding a screen with options would make the interface complex and confusing. Maybe this screen could be created in future.
- Taking daytime and season into account when selecting recommendations. These two features are not available in Flickr. Hence, there is no way to retrieve them and include in algorithms.

After mDS-RecSM prototype was finished, researcher started a quick and dirty test.

7.3 Quick and dirty: initial explorations of usage testing

As planned in “4.3 Recommender implementation plan” the researcher conducted a simple quick and dirty test after completing the prototype. The goal of this test was to fix unexpected critical bugs in the prototype and check the research methodology.

The test started in Teleborg Castle with 2 users. It incorporated every step from a planned case study excluding online post-survey. The excursion went smoothly as planned. Participants were introduced to their task, listened to a story about the castle and made photos. Researcher made small field notes during excursion. Basically, on this stage there was not much to note so it was easy to combine this duty with telling a story about the castle.

The first problem appeared after excursion had finished and participants were asked to create a story. When participants moved from a castle to a classroom in university campus the recommendations changed drastically. 50% of recommendations were not connected to castle theme. It was not possible to conduct a study with such conditions. Hence, it was decided to move back to the castle and create stories there. A possible future solution for this problem would be to allow user mark a geo location on a map and take pictures from their instead of a current device location.
The next problem was related with Internet connection. The Wi-Fi Internet speed in the castle is very low. It influenced the process of sharing pictures. After participants selected all pictures for sharing, only 10-15 of them got uploaded before server returned a time-out message. As a result, after quick and dirty test the number of simultaneously selected for sharing photos was limited to 10. Besides, in case of any upload error, user would get an appropriate message with explanations.

After not a very smooth start, both participants finally began making a story. Few comments were made about the functionality during this process. The most important of them were two suggestions: hide phone keyboard when clicking outside any element on the screen and add “load more” button in recommender. The latter was proposed by both users. They really liked recommendations and wanted to watch even more. Therefore, the mDS-RecSM application was modified to satisfy those demands.

When doing an interview, researcher got a tip from one of the users. The advice was to replace written filed notes with audio record. This idea was approved for interviews part because it saved researchers time and effort. Moreover, it allowed analyzing all the responses step by step without missing a single word.

All other aspects of application and case study methodology in general have passed the test: the interviews went well, the amount of recorded data was enough for analysis, etc. The researcher got necessary information from the test, interesting ideas about recommender from users and a good background to conduct the main study.
8. CASE STUDY OUTCOMES

The preparation for case study is described in the beginning of this section. According to plan (see “5. Design of the study. Step 3.”), three data collection sources were utilized in a case study: direct observation, personal open-ended interviews and distant anonymous survey. Results for data collection with the help of every method are presented in sections 8.1 and 8.2.

Preparation for case study began even before quick and dirty test. Researcher looked through different websites in search of information about Teleborg Castle. After gathering main facts he went to the castle, walked through all the floors with noting interesting places and talked to local worker. The worker elaborated some parts of the castle story and helped in arranging time for next visits. Besides, the narrative was supplemented with a part about current situation where the activities and business perspectives of castle were mentioned. The excursion was ready at that point.

The next task was to prepare other materials. mDS-RecSM was installed on three IPods v.4 with iOS 6.1 and mDS on another three. Interview questions were structured and written on a separate paper.

After everything was ready researcher contacted 10 participants that were already used during gathering requirements (see section 6 for details). All of them agreed to take part in the study and were given an appointment. Two users from quick and dirty test (see section 10.3) were not invited.

The group size and structure was changed by researcher. Instead of taking two people at the same time and giving them different version of application (with and without recommender) he created four groups of participants:

- Group 1. Two users, both male, no recommender;
- Group 2. Two users, both male, with recommender;
- Group 3. Three users, 2 female and 1 male, no recommender;
- Group 4. Three users, 2 female and 1 male, with recommender;

Such grouping would help to avoid unnecessary interactions between users with and without recommender. Also, it decreased the number of visit to castle from 5 to 4.

Researcher met every group near the castle before the excursion. He explained basic information about the ongoing research and specified the task. Then all group members were given mobile phones with preinstalled application. Excursion started from the bottom floor of the castle and continued through all floors to the roof. Researcher took field notes during that process. All participants were really excited to hear the story of Teleborg castle. Few of them even asked additional questions or wanted to hear extra stories about main figures from the plot. Almost half of people asked not to hurry so they could walk more around the floors. From researchers notes it can be concluded that all users enjoyed the process.

When walking around the castle participants took pictures of most interesting objects pointed by narrator on the given devices. Also most people took pictures of themselves or other group members. Some users made interesting photos that were not part of excursion: the stairs inside the castle, the surrounding area and the lake, old chairs, cafeteria, etc. In general, users did the same thing as during usual excursion to historical monuments (Fig. 28).

After excursion participants stayed in the castle and were asked to create stories about any topic connected with it. Though users within the same group could share a story idea, some thoughts on the application or comment the interface, they were asked to work individually on the task. Researcher observed and recorded their behavior during the process. Results are described in the following section.
8.1 Direct observation

Aside from field notes, researcher took data from log files and resulting stories. The received data is shown in tables 5, 6 and 7. People that used prototype with recommender are marked with *. The sorting in the tables was done in two steps: first people were divided into two categories depending on the application version and then sorted by sex in terms of every category.

<table>
<thead>
<tr>
<th>User</th>
<th>Sex</th>
<th>Group</th>
<th>Theme</th>
<th>Photos taken</th>
<th>Photos shared</th>
<th>Photos used</th>
<th>Recom. viewed</th>
<th>Recom. used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Female</td>
<td>3</td>
<td>Castle lights</td>
<td>25</td>
<td>10</td>
<td>9</td>
<td>Not available</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>3</td>
<td>Love story</td>
<td>34</td>
<td>16</td>
<td>8</td>
<td>Not available</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Male</td>
<td>3</td>
<td>My visit to the castle</td>
<td>26</td>
<td>10</td>
<td>7</td>
<td>Not available</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Male</td>
<td>1</td>
<td>Castle fireplace story</td>
<td>10</td>
<td>0</td>
<td>3</td>
<td>Not available</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>1</td>
<td>Modern business castle</td>
<td>25</td>
<td>18</td>
<td>10</td>
<td>Not available</td>
<td></td>
</tr>
<tr>
<td>6*</td>
<td>Female</td>
<td>4</td>
<td>Castle furniture</td>
<td>33</td>
<td>17</td>
<td>13</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>7*</td>
<td>Female</td>
<td>4</td>
<td>Nature around castle</td>
<td>15</td>
<td>9</td>
<td>8</td>
<td>35</td>
<td>6</td>
</tr>
<tr>
<td>8*</td>
<td>Male</td>
<td>2</td>
<td>My visit to the castle</td>
<td>61</td>
<td>40</td>
<td>19</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>9*</td>
<td>Male</td>
<td>2</td>
<td>My visit to the castle</td>
<td>45</td>
<td>25</td>
<td>12</td>
<td>40</td>
<td>4</td>
</tr>
<tr>
<td>10*</td>
<td>Male</td>
<td>4</td>
<td>My visit to the castle</td>
<td>31</td>
<td>16</td>
<td>11</td>
<td>20</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 5. Parameters of stories created by participants. Part 1. (mDS-RecSM version is marked with *)

<table>
<thead>
<tr>
<th>User</th>
<th>Sex</th>
<th>Narrative approach</th>
<th>Genre</th>
<th>Workfl ow steps</th>
<th>Story length</th>
<th>Creatio n time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Female</td>
<td>Describe all lights in castle</td>
<td>documentary</td>
<td>8</td>
<td>0:42</td>
<td>18:00</td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>Castle owners love story + own love story</td>
<td>romance</td>
<td>7</td>
<td>0:40</td>
<td>23:00</td>
</tr>
<tr>
<td>3</td>
<td>Male</td>
<td>Describe interiors and own participation</td>
<td>documentary</td>
<td>9</td>
<td>0:59</td>
<td>15:00</td>
</tr>
<tr>
<td>4</td>
<td>Male</td>
<td>Make up own story about one object from the castle</td>
<td>comedy</td>
<td>5</td>
<td>0:35</td>
<td>8:00</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>Account on facts, describe nowadays castle</td>
<td>documentary</td>
<td>12</td>
<td>0:50</td>
<td>15:00</td>
</tr>
<tr>
<td>6*</td>
<td>Female</td>
<td>Describe all furniture in castle</td>
<td>documentary</td>
<td>9</td>
<td>1:11</td>
<td>20:00</td>
</tr>
<tr>
<td>7*</td>
<td>Female</td>
<td>Describe castle surroundings</td>
<td>documentary</td>
<td>10</td>
<td>1:22</td>
<td>13:00</td>
</tr>
<tr>
<td>8*</td>
<td>Male</td>
<td>Describe interiors and own participation + small horror scene in the end</td>
<td>docum./horror</td>
<td>10</td>
<td>1:32</td>
<td>26:00</td>
</tr>
<tr>
<td>9*</td>
<td>Male</td>
<td>Describe castle + own participation in a funny way</td>
<td>comedy</td>
<td>12</td>
<td>1:24</td>
<td>23:00</td>
</tr>
<tr>
<td>10*</td>
<td>Male</td>
<td>Describe interiors and own participation</td>
<td>documentary</td>
<td>8</td>
<td>1:12</td>
<td>21:00</td>
</tr>
</tbody>
</table>

Table 6. Parameters of stories created by participants. Part 2. (mDS-RecSM version is marked with *)
Photos recommended by Algorithm #1 were chosen 3 times; Photos recommended by Algorithm #2 were chosen 2 times; Photos recommended by Algorithm #3 were chosen 6 times; Photos recommended by Algorithm #4 were chosen 2 times; Photos recommended by Algorithm #5 were chosen 0 times.

As it can be seen, 5 picked recommendations were received from tag-based algorithms (algorithms #1 and #2) and 8 were received from geo-based algorithms (algorithms #3,4,5). The most picked algorithm was based on combination of geo coordinates and searching for story tags in picture parameters (#3). The least popular algorithm was based on interestingness (#5). It received zero picks among users.

There were other measured parameters besides mentioned above. They either showed the same values for all participants or need to be described separately:

- Convenience of the interface. According to researcher observations, all users were pleased with the interface of recommender and application in general. After a one minute introduction they could easily start working in mDS-RecSM. The only confusing part was the “change workflow” button. But it didn’t seriously affect the process of story creation. User opinions on the interface are described in “Appendix A”.
- Amount of times when interface mislead a user. For recommender interface this value remained on a zero point throughout the whole study. As for general workflow, it seemed clear and convenient for users. The only noticed trouble was connected with “Finish” button on the last screen of application. Few users didn’t read the help text and pressed “Finish” just after pressing “Play”. They thought that there will be a separate screen to watch resulting story.
- Cases when user is losing control of the system. None of user lost control of the system during study. It was easy to recover even when user got few errors because mDS-RecSM automatically saves all data on every step of workflow.
- Complexity of system for new users. People that are quite good in computers and technology took part in this study. The system seemed really easy to be learned for them. Though some of participants required little hints from researcher, it didn’t influence the process significantly. Further research with less competent computer users should be conducted to make an overall conclusion about the system complexity.
- How often users are disrupted from story creation. Most users immersed in the creation process completely during study. They stopped only in case of errors or when they required a hint. As we can see from table 7, it happened relatively rarely. From the other hand, participants were quite good in modern technologies so this could influence their involvement.
- Possible conversation between participants. Usually people didn’t talk with each other during story creation. Probably, they didn’t want to show their idea to others until the story is finished. This parameter can probably change in less constrained situations. For example, when researcher asks to create a story collaboratively.
- The active discussion in most cases started after all group members finished their stories and showed them to each other. This discussion mainly didn’t touch the recommender or the application so it is not described

<table>
<thead>
<tr>
<th>User</th>
<th>Sex</th>
<th>Errors or program terminations</th>
<th>Time in errors</th>
<th>Help needed outside app</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Female</td>
<td>1</td>
<td>0:21</td>
<td>Little</td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>0</td>
<td>0:00</td>
<td>Little</td>
</tr>
<tr>
<td>3</td>
<td>Male</td>
<td>2</td>
<td>0:55</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>Male</td>
<td>0</td>
<td>0:00</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>2</td>
<td>1:25</td>
<td>Little</td>
</tr>
<tr>
<td>6*</td>
<td>Female</td>
<td>0</td>
<td>0:00</td>
<td>Little</td>
</tr>
<tr>
<td>7*</td>
<td>Female</td>
<td>1</td>
<td>0:14</td>
<td>None</td>
</tr>
<tr>
<td>8*</td>
<td>Male</td>
<td>2</td>
<td>0:45</td>
<td>Little</td>
</tr>
<tr>
<td>9*</td>
<td>Male</td>
<td>3</td>
<td>1:22</td>
<td>Much</td>
</tr>
<tr>
<td>10*</td>
<td>Male</td>
<td>1</td>
<td>0:34</td>
<td>Little</td>
</tr>
</tbody>
</table>

Table 7. Parameters of stories created by participants. Part 3. (mDS-RecSM version is marked with *)
within current research. User opinions on the system and discussion about mDS-RecSM are shown in the “Appendix A” and section 9.

- Reaction on events happening during story creation. The reaction changed drastically depending on user and the happening event. Errors usually caused discontent or confusion. The process of creation was perceived differently: from a fun task with a smile on the face to serious duty comparable to some school exam. Few users had zero emotions at all. Interesting to note that during interviews they explained reasons behind that (see “Appendix A”).

From researcher point of view, all users were really engaged in the process. Most of them liked this experience and expressed positive feelings during story creation. The users’ point of view on the same process will be discussed in the post-study interviews.

After creating stories every participant was interviewed individually. The results of this process are described in the following subsection.

8.2 Personal interviews and the survey

The interviews were recorded on audio device with parallel short written notes by researcher. The key principles for creating interview questions are described in “5. Design of the study. Step 5.” section.

The answers on interview questions are provided in appendix A. Some repetitive or offtopic answer were excluded from this thesis. Participants that worked with mDS-RecSM version had extra questions for evaluating recommender. Participants with usual version had extra questions about possible addition of recommender in the prototype and its impact on story creation. The analysis of received data is provided in section 9.

After the study all users filled out an anonymous survey. It was e-mailed to people with a demand to return it in a week or less. This allowed them to answer the questions without rush. Questions of the survey were partially taken from Chen & Pears’ evaluation framework for recommendation systems (see “5. Design of the study. Step 5.”). They were adapted for current study; few questions were added to evaluate the recommender influence on content reuse and storytelling in general.

The survey for participants that worked with recommender contained few extra questions to evaluate the recommending system. All questions were answered based on a 5-point Likert scale from 1: “strongly disagree” to 5: “strongly agree”. Questions and answers from the survey can be seen in appendix B. The discussion that touches both survey and interview results is available in the following section.
9. DISCUSSION AND CONCLUDING REMARKS

The analysis of all received data and discussion of findings is done in this section. The analysis starts with comparative evaluation of created stories within two user groups: with and without recommender. The comparison of user perceptions within same groups follows afterwards. This is required to understand the influence of recommender on the storytelling process.

The application aspects such as the interface, ease of use, impact on content creation and distribution, errors and others are analyzed afterwards. Some of these aspects were evaluated to understand whether they influenced research results (for example, gaps in the interface or errors can destroy the whole study). Other analyzed aspects of application are directly connected to the research question.

The analysis of RecSM, its effectiveness and influence on digital storytelling finishes the discussion. The section ends with conclusion that answers research question and summarizes main study results.

9.1 General analysis of created stories

The interesting tendency that is visible from table 5 is that female participants always chose some unique story topics while most male participants preferred to tell a story about their visit to the castle. Story genre was varying not so often. Most participants created a simple documentary narrative.

If comparing stories from two groups of participants (with mDS and with mDS-RecSM version) shown in tables 5 and 6, it can be said that mDS-RecSM users created much longer stories with more pictures: the total amount of taken pictures for mDS-RecSM is bigger, they shared and used more photos (except for user 7 which breaks the tendency). Moreover, users with recommender utilized an average of 2.5 suggested pictures in their stories. Hence, the stories of mDS-RecSM users (except #7) are twice bigger then stories created with mDS. As for bigger amount of shared pictures, probably users were more interested to publish content when knowing that it will be used in recommender system of the application.

The amount of passed workflow steps also is higher for users with mDS-RecSM application. It seems that the need to study a bit more complex recommender interface makes participants carefully study and use other parts of the workflow.

The story creation time in the current study was higher for mDS-RecSM users (again, except #7). Most likely, this happened because of two reasons: the need to study recommender functionality and bigger total length of created stories. A clear connection between using recommender and story creation time can’t be established after conducted research.

After analyzing answers on question 1 of the interviews it can be said that most users first formed the story idea and stack to it. The recommender influenced this only in one case where pictures helped user 7 to find a story topic. So suggested content may rarely influence the first steps of storytelling. Hence, showing recommended photos that are highly different from the story theme would be a mistake. Participants won’t change their topic because of that. Instead, they would be unsatisfied with irrelevant recommender. Users told during gathering requirements that they need similar content in suggestions. The conducted study proved that.

9.2 General user perceptions

Researcher already mentioned in “8.1 Direct observation” section that reaction on events happening during story creation was quite different. At the same time all users were really engaged in the process of story creation.

Users described their feelings in question 4 of the survey. In general, they were positive. It’s important to mention that 2/5 mDS users described application as “just a tool”. They didn’t express much fun or interest. In their opinion the application just helps to solve some tasks. From the first sight it can be said that recommender adds fun and positive emotions to storytelling. But if thinking wisely then these numbers are not enough for drawing such conclusion. Moreover, Frohlich D. et al. mentioned: “Our findings reveal the highly personal nature of mobile storytelling, even in this community context.” (2009). A bigger research is absolutely required in this direction.

Besides, in every group of users (with and without recommender) there was one person who mentioned novelty and two users who expressed real fun. All these facts tell that digital storytelling was mostly perceived positively by study participants and RecSM didn’t ruin such perception.

As for question of benefiting from interactions with a system, all participants gave different answers (Fig. 36). An average of 4/5 was received in this case. It shows that in general users rather benefitted from interacting with the system and recommender didn’t really influence this process.

Though participants liked the experience, most of them will look for analogs on the market because current application is not available (see question 7 of the interviews). The important difference in answers between mDS and mDS-RecSM users was that few participants without recommender noted that application was missing
something. The same tendency was proven in question 3 of the survey (see Fig. 31). It appears that RecSM takes attention away from some technical drawbacks and improves general user opinion towards the application.

Answers on question 4 of the survey (Fig. 32) showed that from user point of view both version of application allowed to efficiently complete the task of creating a digital story. According to participants, the recommender didn’t make an impact in this case. The same opinion touches the question of becoming productive with the help of application (Fig. 35). Both versions were really good in this task according to users.

Question 17 of the interviews proved that mDS-RecSM users liked working with recommender. All of them named examples where they would like to see current system. Though examples were quite different, all participants saw a potential in RecSM.

9.3 Application analysis

9.3.1 The Interface

The interface is very important part of application, especially on mobile phones where “visual feedback is often poor and people have to stare into the device… it’s also difficult to have clear control over the functions” (Benyon D., 2010).

According to both researcher and users, participants were pleased with application interface. Though some small confusing moments (“Change workflow” and “Finish” button) were present during the study, the application interface didn’t negatively influence research results.

A conclusion that can be made out of answers on interviews question 1 is that the developed workflow is really though-out. Most users felt natural to create a narrative step by step. Therefore, the application design positively influenced results of the main study.

If talking about recommender interface, everyone agreed that it was really convenient, simple and though out. It never misled a user. The only remarks connected to recommender appearance were made in question 12 of personal interviews. There users asked for tuning in the visibility of the system: user 6 wanted to hide it and user 7 wanted to make it more noticeable.

9.3.2 Ease of use

The researcher pointed out that mDS/mDS-RecSM was easily studied by participants (see “8.1 Direct observation” section). Users proved this though in question 3 of personal interviews. Although some people had small questions about functionality it didn’t matter too much in terms of learning how to use the application. Besides, few people were new to iOS and required help with that.

In general, answers on question 1 of the survey (fig. 29) proved that for competent computer users it was easy to start using both the application and the recommender. The convenient interface, visual workflow and build-in help messages have done their job. But further studies with other groups of participants are absolutely required to draw a general conclusion on this criterion.

9.3.3 Impact on content creation and distribution

When asked if the application encouraged creating content, most mDS users were hesitating (see question 5 of the interviews). At the same time most of them admitted that creating stories is more interesting than simple photo sharing. In other words, having an installed mDS application would improve the quality and amount of produced content by replacing fragmentary photos and audios with digital narratives.

mDS-RecSM user were more confident when answering same question. 80% of participants that utilized recommender mentioned that they would create less without having the application (see question 5 of the interviews). A very important note is that one of the users underlined the importance of recommender in this context: “I would not be able to create a story about castles surroundings without having recommendations”.

As it appeared from user answers, the application with recommender encourages creating content more than usual storytelling application. Although it should be noted that digital storytelling as an approach also might encourage some users to create more.

When it comes to sharing, a clear conclusion can’t be made. Both mDS and mDS-RecSM users gave varied answers (see question 6 of the interviews). Some people would share stories selectively, some were against sharing and some didn’t want to lose the just created narrative. A good explanation to such diverse opinions on sharing was given by user 1: “It depends on a person. Those who share every minute of their life on Facebook will definitely like this function”.

If talking about other effects of recommender such as impact on the speed of story creation or improved learning (questions 9 and 11 of the survey: fig. 37) then user opinions divided too widely. An extra research with bigger group of participants is needed to make a clear conclusion in this situation.
9.3.4 Errors
As it can be seen from table 7, the mDS-RecSM prototype is not ideal. Most of the users got some errors during story creation. Part of errors was connected with Internet problems; part was just unexpected program termination. One way or another, participants didn’t really suffer from that. Even in worse cases it took not more than 1.5 minutes on recovering from errors. Moreover, users didn’t require much help when errors occurred (see table 7 for details). Based on received data it can be said that errors didn’t affect the results of research.

9.3.5 Control
The control over the application can be lost because of two reasons: constant errors or intrusive system behavior. As it was mentioned above, errors never led to total loose of control during the study. As for intrusive behavior, all users told in question 14 of the interview that the system never took away control from them. This fact was additionally proved in surveys question 2 (fig. 30) where an average 4.8/5 was given to “control over the system” feeling.
When interviewed, user 8 perfectly drew a line in this discussion: “The system helps but at the same time never thinks instead of you”.

9.3.6 Trusting intentions
This part of application can be evaluated by two parameters: intention to purchase and intention to return. These parameters were measured with the help of surveys question 5 and 6 (Fig. 33 and 34).
After analyzing answers it can be said that trusting intentions were almost the same for users with mDS and mDS-RecSM application. Users of mDS-RecSM were hesitating when asked about intention to return to application without having a recommender. In question 16 of the interview and question 12 of the survey (Fig. 37) their opinion divided. Some didn’t want to try mDS because recommendations helped them a lot and some just liked the storytelling process.
It appears that a bigger group of participants is needed to make clear arguments about the influence of recommender on trusting intentions. From the other hand, it is obvious that trusting intentions are high independent of having a recommender system.

9.4 Recommendations analysis

9.4.1 Viewing recommendations
According to tables 5 and 6, the amount of viewed recommendations varied from 15 to 40. This is quite a big number that shows participants interest in recommended content.
Both groups of users (with or without recommender) had a possibility to describe their opinion on recommendations. People who used mDS version were asked if they wanted to view through recommended content while mDS-RecSM users were asked to tell if they actually looked through recommendations during tests.
All mDS users agreed that it would be really great to have some sort of recommended content in the application (see question 8 of the interviews). Some of them though it would inspire, some told it would supplement their story, some just wanted to see the castle as it looked hundred years ago. In every case the reason was different but the main though was the same: participants missed a recommender part.
When asked about viewing recommendations (see question 10 of the interviews), mDS-RecSM users agreed that it was a nice possibility. Some participants browsed pictures carefully while some scrolled quickly. Users 6, 9 and 10 noted that recommendations opened something new for them: an interesting building, a room or the whole castle in different season of the year. Besides, users 7 and 10 mentioned that recommender helped to complement a story by supplying it with details.

9.4.2 Using recommendations
The amount of recommendations used in stories during was differing from 0 to 6. If compared to the total number of utilized pictures then recommended content occupies approximately 15% of the stories. This number shows the recommender impact on digital storytelling. Simultaneously it must be noted that 80% of participants used at least one recommendation in their story.
As in case of viewing recommendations, all participants were asked about using them in a story. The difference in question was also the same: mDS users needed to predict while mDS-RecSM users were asked to evaluate their experience.
Questions 9 and 10 of the interviews proved that both groups of participants could not agree on the use of recommended content in a story. Some people just don’t want to use the work of other people while creating own digital story. From the other hand, a number of stories were hardly dependent on recommendations.

Based on the current study it appeared that a possibility to add recommended content in a story would help in one way or another to approximately 60 percents of users. It also can be said that reusing content from social networks strongly depends on the individual character features and a story plot.

9.4.3 The algorithms

Not all algorithms that were chosen by users during gathering requirements had the same popularity during tests. The sorting based on the number of likes appeared to be a total disaster. In question 15 of the interview two users underlined that photos from the like-based algorithm were “totally out of the topic”. Though it was the least chosen sorting method during gathering requirements (20% of votes) it was not picked a single time in the study.

If talking about other sorting methods, their picking percentage was also different from the number of votes. “The accuracy of matching” sorting was voted by 50% of users but picked by 85% of users. “Creation date” sorting was chosen by 30% and picked by only 15% of participants. Question 14 of the survey (Fig. 38) completely proves these results. Most users were not satisfied with applied sorting methods giving them an average grade of 3/5.

From the other hand, geo-based algorithms proved their potential. After receiving 70% of votes in gathering requirements they scored 65% picking rate during the study. Tag-based algorithms also had similar percentage of votes (30-40%) and picks (35%) among participants.

When asked about choice of recommended content, most users exactly named the algorithm that provided picked photos and explained their opinion (see question 11 of interviews). As for motivation for choosing particular pictures, it was mostly based on how good they fitted a story plot. It can be concluded that in the current study users were consistent in their desires and actions in relation to algorithms.

9.4.4 Recommendations quality

In questions 14 and 15 of the interview participants indicated that recommendations were not ideal by giving an average 3/5 to sorting system and 3/5 to relevance. In general, the quality of recommendations was described by user 6 during interview: “I would say it’s 50/50. There were both good and bad recommendations.”

In terms of recommendations diversity users agreed that it was quite high – an average 4.4/5 was given during the survey (fig. 38). But in the current case diverse didn’t mean relevant. In future diversity can be traded for better quality.

As for the media format of recommendations, opinions divided. According to question 13 of interviews, most users were pleased with pictures as a main recommended media. Some participants expressed their desire to have other types of recommended media. This can be considered as future work. As for current format, pictures provided all possibilities to conduct a high quality research.

9.5 Conclusions

The conducted study in Teleborg castle (Linnaeus University, Sweden) revealed that RecSM combined with mobile digital storytelling induce people to create more content then in case of having a standard mDS application or simple camera application with a possibility to share photos in social network (see sections 9.1 and 9.3.3 for details). Partially this happened because creating digital stories is more interesting than making plain photos. But the analysis of created stories, participants’ interviews and survey results showed that there is obviously a merit of RecSM in it.

Based on the study outcomes analyzed throughout section 9, the answer to a main research question of this thesis is: in most cases the content reuse is supported both directly (adding a recommended content into own story) and indirectly (looking through suggestions, getting ideas or insights and applying them to own story) by RecSM during the process of mobile digital story creation. At the same time the reuse itself depends on the user individuality (some people are against using the work of others) and story characteristics (some stories are more dependent on suggestions than others).

As for the effect of content reuse, the participants with RecSM created much longer stories with more details. So in general, it can be said that the developed RecSM mechanism in mobile digital storytelling application is a possible way to support the successful content movement cycle (Fig. 3). This can be a huge step towards restoring the balance between content creation and consumption on the Internet.

When discussion touches the influence of recommender on content distribution, the clear conclusion can’t be made. It appears that sharing in general heavily depends on personality: some people like to post materials in social networks and others just keep their life in private.

Moving to additional research questions, the following answers were received:
**RQ 1. How much control over the actions does the user feel when using recommendations in mDS?**

According to users and analysis of received data provided in sections 9.3.4 and 9.3.5, participants felt in total control over their actions in the current study. The developed recommender was not intrusive and allowed participants to think and create by themselves. The suggestions supported the process when it was needed.

**RQ 2. How RecSM influence the duration of digital story creation on mobile devices?**

Though the story creation time of mDS-RecSM users was higher, this can be connected with the need to learn recommender, view through suggestions and general story length (which in most cases was much bigger when using recommender). It can be concluded that during acquaintance phase RecSM increases the duration of story creation but further research is needed to get the full pattern.

**RQ 3. What is the dependency between using RecSM in mDS and intention to use the application again in future?**

According to study results and their analysis (section 9.3.6), the intention to use the application again was relatively high independent of having a recommender system. A study with a bigger group of participants is needed to completely answer this question.

As for the general quality of developed recommender, it was relatively good. Though recommendations were evaluated by users with only 3 points out of 5, the general perceptions were positive (see section 9.2). Most users noted that recommendations helped them to create a story or to find out something new. Besides, participants highly appreciated the recommender interface and the ease of use. The high potential of developed recommender system was also noted.
10. FUTURE WORK

Possible future lanes of development and investigation could be oriented towards these two directions:

- Study the developed recommender and upgrade it with new possibilities;
- Add new functions to mDS-RecSM application and study their impact on digital storytelling.

Both directions are perspective and incorporate smaller research or development practices. More detailed description is shown below.

10.1 Study the developed recommender

10.1.1 Analyze recommender algorithms

Though in current research users were asked about preferred algorithm during gathering requirements and then checked with the help of system logs, there are many more ways to retrieve or sort recommendations.

In general, recommenders for mobile phone are relatively new and developing area especially when taking geo location into account. It should be studied carefully because in the current research most users were interested to receive geo-based suggestions (see Fig. 19).

Besides, the effectiveness of already tested algorithms can be counted mathematically. If going deeper in this field, researcher can develop an own algorithm for picking recommendations based on the mixture of existing approaches or even by creating own formula. In such case the algorithm should be tested on practice and compared with competitors. It will require much bigger group of participants then in current study.

10.1.2 Increase the scale of research

“A journey of a thousand miles begins with a single step.” (Lao-tzu, Chinese philosopher, 604 BC - 531 BC)

Current research was a one-time case study with 10 participants. Surely received tendencies can’t be considered axioms with the help of such numbers. They rather became theorems that need to be proven with large scale studies.

At the same time, the important outcome of this work is that researcher showed prospects of recommenders in digital storytelling. It is a first study conducted in this direction so the idea was not to jump above the head but to make a confident first step.

10.1.3 Study a self-adjusting algorithm

The mechanism that should improve recommendations after similar stories are created in mDS-RecSM was described (see section “4.5 Improving recommendations” or Fig. 9 for details) and implemented (see “10. Implementation of mDS-RecSM application” section) by researcher. But the amount of likes was taken into account only in one out of five recommender algorithms. The reasons behind that are described in “7.1 Recommender algorithms” section. Moreover, the amount of likes for pictures uploaded many years ago was much higher than for photos uploaded with mDS-RecSM. Add the fact that there were only 7 participants with recommender (5 in the main study and 2 in quick and dirty test) which created mostly unique stories and it turns out that recommendations couldn’t be really improved during case study. Hence, a self-adjusting recommender mechanism must be tuned in and studied carefully in a separate research.

10.2 Upgrade recommender with new possibilities

10.2.1 Recommend more media formats

Many users expressed their desire to see recommended music, audio or video (see Fig. 15 and “Appendix A. Question 13”). These features will not just modify the application - they can greatly influence the results of research. For example, it would be really interesting to find out how recommended videos from YouTube may influence content reuse in mDS-RecSM. Another possible research topic in this direction is studying how different types of recommendations change the process of digital story creation.

10.2.2 Recommend content from various social services

Another feature suggested by users was to take recommendations from popular social networks such as Facebook or VKontakte (see Fig. 16). The support of different social services as a source of recommendations could
greatly increase user experience. It would also allow collecting data from user profiles and using it in new recommender algorithms for providing more accurate recommendations.

Except from studying profile based algorithms, this feature provides good possibilities from the point of research. For example, it would be interesting to study the quality of recommendations depending on their source.

10.2.3 Add recommender options

A separate screen with options was requested by one of participants even on the stage of gathering requirements. The researcher decided not to implement it because it could ruin the interface.

As it appeared during the study, most participants would be glad to manually tune in several parts of recommender or even hide it in some cases. From the other hand, creating window with options requires separate study of the program interface. The whole workflow would change in case of implementing such system.

Besides, it is not clear what recommender parts should be manipulated by user and what parts must be switched programmatically. If given too much freedom, some people may appear in a situation with totally irrelevant recommendations. Such cases would totally ruin user experience. Therefore, options screen must be developed carefully.

10.3 Add new functions to mDS-RecSM application

10.3.1 Content tags and descriptions

The possibility of tagging pictures was described in “7.1 Recommender algorithms” section. This function would provide more accurate situational recommendations. In case of Teleborg castle, such system would show not just general pictures but concrete photos of objects or rooms.

The tagging system for pictures was not implemented to sustain simplicity. But in future it has a potential to increase user experience and quality of recommendations.

Another similar feature would be adding description to photos and a possibility to read description of every recommended piece of content. In this case some recommendations would turn up from a different angle or supplement a narrative with facts.

10.3.2 Mapping stories

Adding some kind of mapping API to application would greatly enhance its possibilities. First of all, users will be attracted with adding geo-location to their stories in the same way as anyone can add coordinates to a picture. Then the idea can be developed to creating routes where checkpoints would mean digital stories from that location. New terms such as “story map” or “mobile geostorytelling” can appear in this case.

10.3.3 User profiles

This feature will allow collecting additional user data which can be analyzed to improve recommendation quality. A collaborative filtering method that was not utilized in current research can be implemented and studied with the help of these profiles.

Besides, the possibility to create profiles can turn mDS-RecSM application into a standalone social service that will be able to compete on the market without relying on third-party APIs.

10.3.4 Adding video function

Creating an opportunity of adding video to a story should improve user experience. Furthermore, all modern mobile devices have camera that can film videos so it is already possible from a technical point of view.

This question was partially discussed in subsection 10.2.1 of “Future work”. Now the idea will be not just to show recommended video to user but to add it in the story. This could completely change the process of digital storytelling and surely will require lots of program changes.

10.4 Adjust application for different devices

10.4.1 Simultaneous editing on different devices

In the current form collaborative story creation is possible on one device. Users can just make decisions as a team and build a combined story. But when the number of participants exceeds 2 or 3, it will no longer be comfortable to constantly pass device to each other. Therefore, implementing a possibility to simultaneously edit the same story on multiple devices would solve the problem.
From a technical point of view it can be done using Internet or Bluetooth. From a practical point of view it will greatly improve interaction between application users and disclose mDS as a collaborative tool that solves different types of tasks.

10.4.2 Adjust sizes for tablet version

The interface of current mDS-RecSM version was designed for mobile phones with iOS system. The program will work on other iOS devices (like tablets) but the interface should be adjusted to better fit bigger screen size. This would increase the potential customer base for developed solution when competing on the market.

10.4.3 Create version for Android

Today the most popular mobile platforms are iOS and Android. Development under these platforms requires knowledge of different programming languages. Hence, developing an Android version of mDS-RecSM would require much time and effort. At the same time, it would increase customer base from 4/9 of the market till 8/9.

Moreover, Android has almost no restriction about copyrights so adding music or video in a story would not be a problem there. In iOS, from the other hand, it will be almost impossible to complete the same task and get to the app market.

In addition to new market possibilities Android version must be studied separately. Android users are familiar with other design patterns and approaches; they behave in a different way and make different moves on a phone screen if compared to iOS users.
REFERENCES


APPENDIX A. INTERVIEW QUESTIONS AND ANSWERS

Note. User numeration in answers is the same as in tables 5, 6 and 7.

**Question 1.** Describe how you created a story. What tactic did you use?
User 1: First I got an idea. Then I made a number of corresponding photos. I placed some of them in such a way that they formed a story. Next I added text to some pictures and a soundtrack. I swapped some photos before creating a final version.
User 2: I got two or three different ideas. Hence, I made lots of photos around the castle. I picked one particular idea when started making a story. After that I chose corresponding photos. Then creation process went step by step: add some text, soundtrack, titles and watch results.
User 4: The idea was plain and simple: describe a castle’s fireplace in a funny way. I photographed fireplace from different angles and then added my story in audio format. I decided not to go through all functions of application because I didn’t need them.
User 5: After making photos about the modern history of Teleborg Castle, I decided to study the mDS application carefully. I went through all screens, checked help messages and asked about hints. Then I created my story step by step using all available tools.
User 6: My idea was to show all furniture from the castle floor by floor. I pictured almost every piece of furniture that I saw during excursion. Then I just picked best photos, composed everything, added some text and a soundtrack.
User 7: During excursion I was really hesitating about the story topic. So I made lots of different photos. When I looked through recommended content I saw really beautiful landscapes. I decided to make a story about castle surroundings. Only few of my own photos were appropriate for that so I used the recommended ones. I decided not to add text to the story. I just put some voiceover on few slides and a nice soundtrack.
User 8 & 9: The process was almost the same as creating a power point presentation in school. The only exception was that used audio in my story. The process looked like this: I took photos, arranged them, added some text and voiceover, added a soundtrack, added some into and outro. That was it.
User 10: It was a simple narrative approach. Add photo, place some voiceover on it then add another photo, record more voice, etc. When I had all photos with voice arranged I changed transitions and added a soundtrack.

**Question 2.** What can you say about application interface?
Most of the users: though there were some unclear moments (“Change workflow” or “Finish” button) in the interface, I think it worked fine for me.
User 3: The “Finish” button was confusing. Why the process stops after pressing it? I though browsing resulting story should be a final step.
User 7: It would be nice if text in subtitles automatically started with a capital letter. Also I want a spell check.

**Question 3.** Was it hard to learn how to use the application?
Users 1, 2, 5, 6, 10: It was relatively easy.
Users 3 & 7: At first it was a bit hard because I am not familiar with iOS devices. I got used to android.
User 4: It was very easy.
Users 8 & 9: Not hard. It required the same time as studying other mobile applications.

**Question 4.** Describe general impressions after working with application.
Users 1&5: Interesting, addictive, fun. That’s what I felt when working with mDS.
Users 2: I didn’t waste my time with this app. Just because of that I would rate it high.
Users 3: I had zero emotions during experiment. It’s just a tool and nothing more. It solves the task quite confidently. I like that.
Users 4: It’s definitely something new for me. I’ve never heard someone using a mobile phone to solve such tasks. It opened a new opportunity for me.
Users 6: It was fun to “play” with the app. Though I would cut some functionality and make it simpler.
Users 7: A totally new experience for me. Emotions were comparable with what I feel when discovering new cute clothes in a shop.
Users 8: Good impressions. I would buy it if it was on the market.
Users 9: It was a real pleasure to make a story and then watch reaction of other people on it. I enjoyed people from my group laughing at my story.
Users 10: It was better than I expected. At first I was skeptical when hearing words like “research” and “study”. These words are associated with some boring staff which I prefer not to do in spare time. But when I sat in the castle hall after a nice excursion and had a chance to tell few words about my visit then I changed my mind.
**Question 5.** Did you feel that the application encouraged you to create content?

User 1: Possibly. Without mDS I would never make a presentation with all this music and voice. It requires too much effort to do it on my notebook. I think mDS was simple, convenient and the same time incorporated all necessary tools to create interesting stories.

User 2: I would use it on demand. I won’t start creating hundreds of stories after this experiment but if I get an appropriate situation then it would be nice to have mDS installed on my phone.

User 3: I think it didn’t encourage me to create content. It’s just a convenient tool that solves a task. If I want to make a story then I will search for a tool. The tool itself doesn’t force me to create something.

User 4: Yes. Creating a number of photos and sending them to someone is very boring. I prefer creating something interesting instead. Stories fit my demands perfectly.

User 6: Hard to say. I need to work with it more to understand it.

User 7: I would not be able to create a story about castles surroundings without having recommendations. So the answer is absolutely positive.

User 8: Yes. Without the application I wouldn’t make anything except sharing few photos from the excursion on Facebook.

User 9: Definitely! Making plane photos is a “stone age”. But during experiment I felt that storytelling is the future.

User 10: The program is convenient. It’s nice to have it on your mobile phone to complete some fast tasks. I think I would create less without it. Surely if you want better quality and more possibilities then you need PC software.

**Question 6.** Would you share your story on the Internet?

User 1: It depends on a person. There are people who share every minute of their life on Facebook. They would definitely share their digital stories. As for me, I would share some of them.

User 2 & 10: I want to share it only with people I know. I would make it “private” on YouTube and send a link to my friends. I don’t want Internet “trolls” to laugh at me.

User 3: If you mean the story I created today then yes, I want to share it. In general, I would share some of the stories. It’s the same as in case of pictures: I would like to choose what to share and what to keep private.

User 4: No, I didn’t really put my effort in it. It’s not worth sharing. But in case I had plenty of time and did a great story then I would surely publish it.

User 5: I already tried. The Internet in the castle is too bad for this. But I’ll try again at home.

User 7: Not in the current moment. I need more professional photos and I think my story is not 100% finished. I will publish it after some modernization.

User 8: Yeah, I tried about half an hour to make it. It should not just disappear into nowhere.

User 9: Why not? I think my story is quite funny. It would make the world better (smiles).

**Question 7.** Would you search for similar applications after working with mDS/mDS-RecSM?

User 2: People will always search for the best. This application requires some additional work to compete on the market.

User 3: With good promotion mDS will definitely shine on the market. I don’t think I would need something in replacement in that case.

User 4: The prototype is good but it is missing some functionality. I would definitely try finding analogs.

User 5: I never used such mobile applications. I need to view the market to answer this.

User 7: I don’t need similar applications. This worked really well for me. All analogs that I used before were quite primitive. So I would rather search for mDS-RecSM on the market.

User 8: Yes, I will look for similar programs. I liked working with mDS-RecSM but it is not available for purchase. Hence, I have to search for a substitute.

User 9: I liked the applications so I will search for analogs.

User 10: I won’t because I worked with similar software on PC and I know that this application has no analogs (in terms of recommendations). As for picture/video editing, PC programs are much powerful.

The following questions were given only to users with mDS version (no recommender system)

**Question 8.** Would you like to have a possibility of viewing similar pictures while creating a story?

User 1: Sure. Having something similar to Google Pictures functionality would be great. I think it would inspire me to create a more complex and though-out story.

User 2: It would be great. My love story was missing romantic pictures. During excursion I heard that nowadays they organize weddings in the castle so I think it would be nice to browse such pictures and get “in the mood”.

User 3: Browsing photos on my topic made by others would be really helpful. They could potentially motivate me to return to some place and make a picture of item that I missed.
User 4: I would like to see some spontaneous pictures from the same object. Maybe it can inspire me on creating something totally new. Also I would like to browse old pictures of the castle.
User 5: Yes. When we had excursion through the bottom floors (the modern business area and a cafeteria) some rooms and a dining hall were closed. I would really like to see what was inside.

**Question 9.** What would motivate you to use pictures from social networks made by other people in your story?

User 1: I think they must incorporate something special. It’s hard to explain. They must be unique and at the same time fit the plot of my story.
User 2: I would use such pictures as transitions between my own images. When making my story I was missing few nice transitional elements that I forgot to photograph during excursion.
User 3: Nothing would motivate me to use pictures from other people. It sounds like someone force me to use his content. I think creating a story from own picture is much better. From the other hand, I already mentioned that browsing works of others could help me a lot.
User 4: Such pictures can supplement a story. For example, my story about a fireplace really missed old pictures of castles fireplace. I was limited to use only own photos that were made during excursion.
User 5: I would not use work of others in my story. I am individualist by nature.

**The following questions were given only to users with mDS-RecSM version** (with recommender system)

**Question 10.** Did you use suggested content in your story? Were the recommendations helpful? Did you get new experience or insight by reviewing work of other users?

User 6: I am that kind of a person that doesn’t rely on others. So I didn’t use suggested content in my story. Besides, recommendations provided me the same objects that I photographed myself. Maybe if I saw something unique then I would use it.
User 7: Half of my story consisted of recommended photos. The system was really helpful and supplemented my story with nice details. The only wish is to have some short description about every picture. In my case it would allow to tell more information about landscapes.
User 8: The only recommendation I used was the general photo of castle from a far distance. As excursion started in the castle I didn’t have an opportunity to make such photo.
In general, recommendations were fine but my goal was to create a story about own visit to the castle. Hence, I just browsed them without utilizing.
User 9: The recommendations perfectly helped me to start and finish the story. They also helped to reveal the plot. In particular, my story was called “the amazing castle” and I saw a sign with this phrase among recommendations. It was an art work in a funny style with a little dragon on it. I remembered this moment because this particular photo helped in creating a comedy story.
Besides, I met some pictures of the castle made in winter. They were really beautiful and inspired me to come back to Teleborg in winter.
User 10: I used few recommended photos taken outside with a castle on them. It was raining when we had excursion so we didn’t have chance to make photos outside.
In addition, when browsing recommended content I saw a really big dining room with a nice chandelier in it. I missed it for some reason when we were walking around. After the end of experiment I want to go and check it.
In general recommendations help to describe a place as a whole. Especially it would work nicely if user was given recommended music and sounds.

**Question 11.** Why did you choose these recommendations and not the others? In your opinion, what algorithms were they based on (location or tags)?

User 6: Though I didn’t choose any recommendation, I felt that the one that caught my attention was based on geo location. My story was about furniture and I wrote appropriate tags for that. Hence, tag-based algorithms showed me the furniture.
User 7: Obviously because they fit my story. I had half recommended photos that were made inside the castle or showed the castle without its surroundings. That’s why I used the other half.
I think that photos based on tags worked out in my case. I have put really clear tags when building a story. As for recommendations based on location, they were not appropriate because I was creating a story inside the castle. It’s just the specifics of my story plot.
User 8: I chose the first available photo of the castle that was made from a distance. I have no idea what algorithms were behind it.
User 9: I chose the photos that seemed quite random from a first sight. But as I mentioned, they really helped to make a comedy story. Half of these photos were obviously received with tag-based queries because there are no
such photos in the castles geo-location. The other half that I used was probably geo-based because I saw Teleborg castle on them though I didn’t mention word “Teleborg” in tags or story title. There are millions of castles in the world so probably I saw the exact castle because of sitting in it.

User 10: I picked the best photos of Teleborg castle made outside. I am not sure which algorithm they were based on. I guess it was some combination of geo- and tag-based system.

**Question 12.** What can you say about recommender interface?

Most users: The interface of recommendations is perfect. The pictures are placed where they should be.

User 6: I would enjoy a possibility to hide recommendations.

User 7: I think you must give a hint to new users that they should look through recommendations. Because customers will not have any help in person when creating a story.

**Question 13.** What about the media format of recommendations?

User 6: Picture format is good for me. I wouldn’t watch recommended videos or listen to recommended music. It takes too much time. Even on YouTube I watch first 5 seconds of most videos. So pictures fit my needs.

User 8 & 9: Pictures are fine. Thought it would be nice to have music and sounds in recommendations.

User 10: Sometimes it’s boring too view hundreds of photos. So I would like to watch recommended videos. Besides, it would be great to have recommended music.

**Question 14.** Do you think recommender system was intrusive?

All users: Definitely not.

User 8: The system is perfect in this sense. It helps but at the same time never thinks instead of you.

**Question 15.** Were recommendations contradictive with your own choices?

User 6: I would say it’s 50/50. There were both good and bad recommendations.

User 8 & 9: The motorcycle was totally out of the topic. The rest was fine.

User 7 & 10: Surely there were few contradictive pictures but in general it didn’t affect me too much.

**Question 16.** What would you answer if you were given an opportunity to repeat this experience without recommender?

User 6: I would probably agree because I liked creating stories in this application. The recommender didn’t matter so much.

User 7: Definitely refuse. Half of my story was created with pictures from recommender. I would really miss it.

User 8 & 9: It’s hard to say. I think I would answer positively just to give it a try.

**Question 17.** Do you think it’s appropriate to use the recommender in other applications?

User 6: Well, I like “find similar” function in Google pictures. It’s fun to just browse photos like that.

User 7: Sure. I would like to see some recommended books in my phone.

User 8: It’s appropriate for travelling websites. Also it would be nice to see some recommendations when browsing maps.

User 10: Yes, I want to see it in scientific topic. There are always tons of scientific articles on the Internet. It’s a total mess. Helpful recommendations would save much time and effort.
APPENDIX B. SURVEY RESULTS

Answers by users of mDS and mDS-RecSM were placed on different plots to be able to see the difference between having and not having recommender.

**Question 1.** The system was intuitively understandable. Answers are shown on figure 29.

**Question 2.** I felt in control of the system when creating a story. Answers are shown on figure 30.

![Figure 29. Answers on post-survey question 1.](image)

![Figure 30. Answers on post-survey question 2.](image)

**Question 3.** This system has all the functions and capabilities that I expect it to have. Answers are shown on figure 31.

**Question 4.** I was able to efficiently complete the tasks using this system. Answers are shown on figure 32.

![Figure 31. Answers on post-survey question 3.](image)

![Figure 32. Answers on post-survey question 4.](image)

**Question 5.** I would purchase this application from the market if it has an affordable price. Answers are shown on figure 33.

**Question 6.** I would use this application regularly in future. Answers are shown on figure 34.

![Figure 33. Answers on post-survey question 5.](image)

![Figure 34. Answers on post-survey question 6.](image)

**Question 7.** I believe I could become productive quickly using this application. Answers are shown on fig. 35.

**Question 8.** I felt that I benefitted from interaction with the system. Answers are shown on figure 36.

![Figure 35. Answers on post-survey question 7.](image)

![Figure 36. Answers on post-survey question 8.](image)

The following question were received only by mDS-RecSM users.

**Question 9.** Recommendations accelerated the process of story creation. Answers are shown on figure 37.

**Question 10.** The list of recommendations greatly supported the process of digital story creation.

**Question 11.** I learned something about the castle from viewing recommended pictures.

**Question 12.** I would have missed the recommender a lot. Answers are shown on figure 37.
Question 13. Diversity of recommendations was high. Answers are shown on figure 38.

Question 14. I feel that recommendations ranking/sorting was good. Answers are shown on figure 38.

Question 15. I suffered from viewing through irrelevant recommendations. Answers are shown on figure 38.