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The Design Scope of Adaptive Storytelling in Virtual Museums

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Abstract

This positioning paper seeks to evaluate how well the current state of interactive storytelling, content recommendation, and Linked Data can increase the efficaciousness of knowledge transfer in the context of cultural heritage. It considers the design scope of various interactive storytelling systems and investigates how the domain of semantic web fosters user satisfaction during explorative browsing by providing recommendations and related concepts. In conclusion, interactive storytelling systems have significant room for improvement in at least two aspects:

1. *By telling a story that includes exhibits and employs their similarities and differences to describe the plot.*
2. *By adapting not only the content but also genre typical patterns to the individual user's taste.*

Furthermore, the required background and world knowledge necessary for interactive storytelling is retrievable from the Linked Data Cloud.

Categories and Subject Descriptors (according to ACM CCS): H.5.2 [Information Interfaces and Presentation]: User Interfaces—Theory and methods I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction techniques

1. Introduction

Years of research have already shown the many benefits interactive storytelling (IS) has to a human learner. Especially in the domain of galleries, libraries, archives and museums it is important to increase the effectiveness of successful knowledge transfer and to make explorative search more enjoyable and coherent, in order to let users learn more.

IS systems can automatically tell stories based on a body of rules and story element input. Current systems mostly chain story elements and let users influence the story to trigger slight variations, which causes a high immersion for the user [THT11]. Some systems even consider which story elements have already been explored [Mur96]. The area of onsite museum guides considers user data as an important basis to present information tailored to individual interests and level of expertise [HSWA10]. This offers the opportunity to employ content recommendation techniques as the area is well researched for many years and provides solid solutions for common problems when recommending content based on user data [BS97, FBH00].

The proposed approach in this paper ties in with preliminary research that revealed positive effectiveness of recommendations, especially for non domain experts in a similar setting to our approach [HSWA10], but we want to go beyond recommendation of related information units and employ storytelling techniques to knit related information units into a story.

2. Motivation

Virtual and physical museums share the same main objectives of archiving, exhibition and education. A possible implementation strategy is through IS; existing research has focused on on-site museum guides which present paratexts of the exhibits, or on IS systems that tell a (non-) fictional story and do not include exhibits. In this paper, *virtual museum* refers to an experience that is not limited to the experience within the physical museum experience, e.g. [Lou14].

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The gap between current virtual museums and the user's demand for interactive storytelling applications has been issued in existing research [Mar08]. Although a consensus exists that knowledge should be presented to each individual differently according to their preferences [Mar08, RTA05, Bru01, BCG10], to the best of the authors' knowledge no research effort has been made to enhance IS in a virtual museum according by these means. There are IS systems that identify a user's preferred topics and tailor the story around the specific content only for the duration of the session [Mur96, THT11, LMG11]. However, adaptations are performed for the period of a session and not persisted across sessions; they do not adapt to the preferred style of storytelling.

Existing research focused on two key areas: on reacting to user input in IS systems, and on exploiting user models for museum guides. To the best of the authors' knowledge, there has been no attempt conducted to discover the potential benefits of merging both strategies. Therefore, it is proposed that IS systems in the context of cultural heritage have two areas of improvement:

1. By telling a story that includes exploiting exhibits and their similarities in a manner similar to museum guides.
2. By adapting not only the content, but also genre typical patterns, to the individual user's taste in a manner similar to IS systems.

3. Literature Review

This section presents works in the domains of cultural heritage, content recommendation and interactive storytelling.

3.1. Virtual Museum

In [Mar08] Marty stated that: "[...] online museum visitors are interested in having access to unique experiences that cannot be duplicated in museums". The majority of museum website visitors likes to interact freely with exhibition images and paratexts whereas the minority likes to interact with fixed, pipelined curated digital galleries. Marty argues: "[...] online museum visitors are developing [...] relationships [to exhibits] mostly on their own initiative". He concludes that a more personal approach is required. Because of a heterogeneous target group, the digital museum must cater to both the expert and the amateur. IS is promoted for this purpose by [Mur96, RSZ*04, Mar08, DGL*08].

3.2. Content Recommendation

Content recommendation is a technique that ranks content for each user differently according to the collected user data, i.e. the user's interests [BS97]. This method potentially serves an individual user the most desired content first. The core of each content recommender is therefore the user data which is usually stored in a user model (UM). A UM holds plain data called evidence that serves as an indicator for the content recommendations [KKL02].

The danger wrought by content recommendation lies in isolation problems. The content recommender may start to choose highly similar content without providing the chance to step outside of the collected evidence. One may overcome this vulnerability through collaborative content recommendation, thereby detecting correlations between users' preferences. For example, if a correlation test for user A and B proves that they share a similar taste in content, then any content viewed by B and not by A can be recommended [BS97].

3.3. Storytelling

Storytelling is the art of narration, employing metaphors, archetypes and patterns to transfer implicit knowledge about our environment [Mur11]. Patterns cause expectations in the audience as they have been identified by Propp who analysed folk stories. He posits that characters serve with functions to advance the plot. For example, the archetype of the villain is an important role with the function of "causing harm" by certain actions [Pro68]. Concretely, Cruella de Ville's abduction of Pongo's and Perdita's puppies in the animated "101 Dalmatians" raises the expectation of rescue. Propp identified 31 different functions, "[...] which can be combined in multiple ways to create stories [...] continuous, overlapping, recursive, or nested [...] [and represent] a shared mental modelling for understanding the relationships among human beings." [Mur11].

Murray elucidates that storytelling does not require complex structures because even simple moves such as delaying a rescue can create dramatic effects. The story's interplay with our mind, triggering anticipation by patterns, is independent of genre because the patterns are derived from our daily experiences and media viewing pattern [Mur11].

3.4. Learning with Storytelling

To achieve the best possible outcome for knowledge transfer, recent findings in the area of cerebral research are to consider. Hüther shows that explorative discovery fosters inspiration, which can lead to enthusiasm and he further demonstrates that enthusiasm is the best condition for successful learning [Hüt11]. In [LTJY14] it is described, that this link between emotion and episodic memory is established by a cerebral area, called *amygdala*. Storytelling has an effect on emotions and is even used in a therapeutic context to successfully reduce negative affects and feelings [PW06]. By triggering emotions, and thereby addressing the *amygdala*, storytelling transfers knowledge which can be memorised better than just plain facts [DGL*08].

3.5. Interactive Storytelling

IS is an experience where the user affects the story, without changing its plot [Mur96]. According to Murray IS fosters the user's immersion, but both the strength and difficulty of interactive storytelling lies within the possibilities of a story's variation. The variation will only be enjoyable if it happens within patterns that identify character roles. For example when the hero outsmarts his opponents in different ways each time the story is told. Therefore, the core challenge is to design a system capable of telling stories that not only allows the traversal of a story, but one that fosters active creation of the story experience [Mur11].

The game *PayDay 2* [Stu13] is a good example of how well designed variations can increase engagement. The user slips into the role of a gangster that earns his keep by robbing banks among others. The scene remains the same, but important details vary with each replay: the position of the surveillance cameras, the number and position of guard personnel, the safe's security measures, and so forth. These variations keep every play-through engaging and challenging. While games mostly focus on genre actions (like robbery), story patterns are an abstraction of genre themes (like punishment). For a storytelling system it is crucial to "look for the underlying causal structures that motivate those actions" [Mur11]. To preserve this underlying causal structure, the degree of freedom of influence should be limited [Mur11]. Without limitation the interaction could harm the story flow. For example: Granting the user to cut the lawn for hours will diminish the suspense. IS systems need to provide a frame within the story can be changed. But restricting interaction possibilities too much will raise the problem of diminishing the user's immersion. For example if an IS system chains cut scenes and offers branching points where the user decides the story's direction, the periods of inactivity prevail which disillusiones the user in their flow. The user must be able to interact during the narrative process in order to steer the story's direction within a given frame [Mur96]. This requires the use of Artificial Intelligence [Szi05].

According to Szilas there are two main problems of IS. The first problem is of technical nature: most research focuses on the elaboration of a proper virtual environment, avatars and other graphic based challenges, but then lack of proper narrative algorithms and interaction possibilities. The second problem is that existing research shows no real interdisciplinarity between the technical and the creative side [Szi05].

3.6. Interactive Storytelling Systems

3.6.1. Digital Museum Guides

Most digital museum guides are on-site. They are used inside the museum as an interactive guide with functionality similar to an audio guide. They provide paratexts to support the visitor's understanding of the exhibits. Paratexts are texts that add meaning to the presented exhibit like descriptions or artist biographies.

Rocchi et al. present a museum guide combining handheld devices, which displays a life-like avatar, with stationary screens that function as an extension of the screen estate [RSZ*04]. The stationary screens make use of infrared beacons to identify approaching handheld devices. If a user approaches a stationary screen, the avatar moves from the mobile device to the stationary screen and more detailed information is displayed. The system provides storytelling by chaining content units according to a semantic relationship. A content unit consists of a text file, which is read aloud by the computer, and images, which are presented in a cinematic slideshow during the playback. Each text-image set is combined with other text-image sets based on their context: each text has a topic and rhetorical relations and each image is tagged according to its content. The visitor's interest is derived from previously visited exhibits and exploited for content recommendation.

Damiano et al. follow a similar approach [DGL*08]. Their system, *Carletto*, is a storytelling agent for mobile devices employing an anchorman. The anchorman tells anecdotes according to the visitor's position inside the museum. Similar to Rocchi's work, *Carletto* presents information units that are also semantically tagged and played back coherently during the visit, but *Carletto* does not provide content recommendation. The evaluation of *Carletto* shows that an anchorman is usually not accepted by the users, as they expect a more serious form of presentation in a detached and objective manner.

Roes et al. present *CHIP*, a web-based museum guide with a focus on creating routes through the museum according to the user's interest [RSWA09]. The interest is gathered both explicitly by user ratings of artworks and implicitly by measuring the time the user spends admiring an artwork, which is derived from the angle the mobile device is held. Both pieces of information are stored in a UM. Based on this data, the system provides content recommendation to semantically related artworks along the dimensions of: same artist, same content and same style. Van Hage et al. developed *CHIP* further, enhancing the real time routing through the museum [HSWA10]. The recommendations for the routing are based on the user's interest and on semantically connected knowledge about the artwork and art concepts. This work elucidates that serving the different needs of each individual is of major relevance.

Lim and Aylett followed a similar approach by presenting a user interest based museum routing guide [LA07]. In contrast to the previously presented systems ideological perspectives are added to the presented output. The output is text, speech and an animated talking head. The user rates the presented facts according to their interest and agreement. This rating affects the content, the guide's ideological comments and the extensiveness of the presented output.

The *CHESS* project employs mixed reality and adaptive interactive storytelling to enhance the physical museum visit [VKK*14]. The story line consists of predefined story elements which are assembled content-wise according to the user's interest. It harnesses a decission theory based cold start problem solution to select predefined personas, that are models of distinct user types. Each persona causes a different form of the narrative. The use of personas is a good approach towards adapting a story not only content-wise but also regarding its form and therefore similiar to the proposed approach, see section 5.1.The main difference to the proposed approach relates to the adaptation of the prefered story genre.

3.6.2. Stationary Interactive Storytelling Systems

IS systems differ in their capability of generating the story told. A straightforward approach is to chain fixed story elements and provide branching points to let the user select which story element should be chained next. The degree of interactivity is tightly coupled to the authoring effort. The more decisions are possible the more story elements need to be written manually. Though it is possible to diminish the effort by creating story elements in a way that they can be used in many different combinations [DV12], the authoring effort is still a constraint.

Murtaugh describes the *Automatist Storytelling System* that presents information entities such as videos in semantical relationships [Mur96]. The approach uses keywords as a means of indirectly defining potential links between materials. He promotes the necessity of providing individual access to the content, which he enables by storing which information unit had already been visited by the user.

Tanenbaum et al. present an IS system that provides no variations of the story but employs a recommender system and promotes story elements that fit best into the current story discovery [THT11]. The narrative and the environment are fixed in contrast to most intelligent IS systems, which attempt to adapt the storyline to user interaction. The work focusses on a recommendation rule engine that is based on three criteria: "Theme, Importance, or Position". Theme is used to evaluate how closely the story element themes matched, the Position criterion is used to weight the story elements according to their chronological order and Importance favors story elements that are more crucial than others, e.g., the main plot over side plot. If the user favors one of these criteria over the others, then that criterion is boosted.

Both models are similarly content-driven to enable the user to steer and shape the story by activating and weighting keywords during playback. How the story elements are linked together is computed during the playback based on the user interaction, but still the problem of the high authoring effort remains.

Façade is an example for a more generative approach. It is an interactive drama and the attempt to create a character-driven story with high degrees of freedom all the while trying to maintain the assembly of story beats such as decisions, events or discoveries [Ste05]. Though it is not possible for the user to communicate freely to the characters, the story elements are more variable by allowing instant interruption and interconnection, triggered by user interaction. The story is framed around an arguing couple and the user's interaction with certain artefacts in the environment or other non-player characters can trigger story sequences. Murray analyses *Façade* with the statement, that "[...] it uses dramatic beats similar to Propp's functions but in a much more complex and generative proceduralised substitution system with multiple rules and parameters controlling the composition of an individual beat, the selection of beats, and the assembly of a sequences of beats." [Mur11].

While *Façade* is a scene-based IS system, other IS systems are action-based. *Defacto*, described in [Szi12] generates stories based on user input. In the first phase the user can choose between options for the protagonist, followed by a resolution phase that selects the best possible outcome by inferring from rules, such as "Accept as plot developments only character intervention affiliated with the current storyline goal" [Sgo99]. After the resolution the story is organised according to the Aristotelian drama architecture. The system is able to detect user preference for a certain character which is reflected in the generated story.

The system *IDtension*, described in [Szi05] also generates stories in interplay with user interaction, but based on entities like goals, tasks, obstacles, actions and characters. Narrative actions are described in abstract concepts like "steal". These concepts are applied to the entities according to a set of actions that are derived from structuralistic theories. The UM is designed according to pragmatics based theories. It is not used to store evidence during the interaction with the system but to hold the knowledge about how a listener is structured. In the words of Szilas: "[...] this model is responsible for expressing the need for surprise or conflict, which then triggers a corresponding action, if available. Current needs are: Ethical consistency, Motivational consistency, Relevance, Complexity, Characterization, Conflict." [Szi03].

Both systems, *Defacto* and *IDtension*, employ characters that handle strategic goals without being capable of reacting directly to the environment [Szi05]

3.7. Linked Data

IS systems need different kinds of data. Exchanging this data between several domains has always been a challenge in computer science. However, in the last years, a paradigm named Linked Data was established to publish data in application-independent, standardised, open file formats.

Linked Data is the peak of a longstanding standardisation effort, that has been originally initiated by the Semantic Web around the turn of the millenium [BLHL01]. Today, Non-Profit-Organisations, authorities and companies worldwide publish their data according to this paradigm and thus contribute to the vision of intelligent, linked applications. Major parts of this movement originate from galleries, libraries, archives and museums, though they usually focus on the creation of the datasets, and not on working end-user applications [EGLM*13].

Recently, Natural Language Processing (NLP) research started using Linked Data resources as background knowledge, which lead to useful, scalable, application-ready frameworks [Gan13]. This trend can be observed in particular in the domain of Knowledge Extraction and Named Entity Recognition, thus both can be considered to be part of a semantic technology as well as the Semantic Web itself [Gan13].

But despite the fact that there has never been more data available than nowadays and the Linked Data paradigm is likely to change the way the Web and the role of data publishers is considered [Stu14], there is a huge demand on Linked Data success stories [GB10].

4. Discussion

4.1. Interactive Storytelling in Virtual Museums

Users of virtual museums demand features not inherent, but complementary to, what is offered in a physical museum [Mar08]. According to the educational mandate of German museums [KOKLS04] it is a requirement for the virtual museum to transfer knowledge as well. Storytelling is suitable for this purpose, as indicated in [LTJY14, DGL*08, Hüt11, PW06]. Users of virtual museums also frequently interact with images and paratexts of the exhibits [Mar08], the key elements of IS in the context of cultural heritage. Current virtual museums, that offer pipelined galleries do not satisfy the user's need [Mar08].

A museum's guide in a physical museum offers tours to a certain topic (story plot), e.g., "Are paintings historical sources?". The guide presents different exhibits and tells the story plot by emphasising on the exhibits' similarities and differences to examine the topic by employing storytelling techniques. To the best of the authors' knowledge, there is no virtual museum that offers a similar experience to the physical guidance of a human being.

The extent to which IS is used in the context of cultural heritage is confined to on-site museum guides, like [DGL*08, RSWA09, HSWA10], that offer dynamic chaining of paratexts in a modular way, without content-related coherence to previously visited exhibits. There are no seamless stories told. The system presented in [LA07] adapts not only the content according to the user's interest but adds also ideological comments to the facts based on the user's agreement. Many thoughts were given to the tagging of content. This work is an important step towards seamless AS in cultural heritage context which we wish to extend. On the other hand there are IS systems capable of telling seamless stories letting the user steer the story like [Mur96, Szi05, Ste05, THT11, LMG11], but they are used outside the context of cultural heritage and therefore do not create dynamic references to exhibits. No approach exists yet, that explores the mutual benefits from both approaches.

4.2. Content Adaptation in the Context of Storytelling

Adapting the content to the user has the benefit of creating more immersive and compelling stories. In the context of cultural heritage adaptive systems are employed to guide the user to exhibits that are of interest to the user, like in [RSWA09,HSWA10,LA07]. In the context of IS user data is not employed in the long term but for the period of a session without persistance across sessions to present content that is of interest to the user, like in [Mur96], or to provide coherence to already presented content, like in [Ste05, THT11]. These systems, including *Defacto*, are based on rules to organise the story affiliation. In *IDtension* a ready made UM is employed to generate the story based on default user needs. The UM is not updated with evidence from user interaction, but holds a priori designed user expectations that help the Drama Manager to organise the story plot [Szi05].

Future IS systems in the context of cultural heritage could benefit in three different ways by employing content recommendation strategies: First, users focus on exhibits and background information that are of interest to them, thus increasing the user's interest in the story and the memorability of the knowledge. They explore only content relevant to them. Second, adapting the story to pre-existing knowledge can increase the interest in the story facts by avoiding to bore the expert and overstrain the novice with the same default text. The text can also vary in length according to user preferences. Like a teacher who knows his pupils and responds to individual prior knowledge can foster their talents better, the IS system's effectivity in knowledge transfer could be increased that way. Third like some guides already provide different pre-selectable ways to explore content, the IS should adapt to the prefered user taste of genres. A genre is defined by its patterns. Different prefered patterns can be mixed to tell stories that are prefered by the individual.

4.3. Linked Data in the Context of Storytelling

Having available sufficient background knowledge is key to IS [Mur96, Szi05, HSWA10, LMG11]. As we have seen in the literature review, the power of IS systems grows with the capability of generating immersive stories, not only linking story elements. This includes knowledge about the collection and its items, knowledge about general storytelling patterns and plots, knowledge about the user (in form of a UM), and certain parts of so called world knowledge - information how relevant parts of the world are related to each other.

We see strong connections between the requirements storytelling has to information technology, and the possibilities that the Linked Data paradigm offers to fulfill information needs. In a technical point of view, storytelling means wiring data together from different sources in order to produce a merged, meaningful broader context. This is exactly the self-understanding that the Linked Data vision has. So Linked Data could be a technical implementation of a storytelling process - by enriching collection knowledge with world knowledge, adjusting it with the user's preferences, and representing it in an exciting story plot. This could also address existing issues in the Linked Data domain, where working solutions are rare and there is no appealing vision to represent the information that are available.

5. Adaptive Storytelling

As presented in the discussion, employing content recommendation strategies can increase the IS's effectiveness by means of knowledge transfer. In this section we suggest a possibly viable approach for IS systems that successfully exploits strategies resulting in an adaptive system, further referred to as adaptive storytelling (AS). The approach is focused on the purpose of knowledge transfer within a virtual museum.

Similar to a guided tour in a physical museum the guide's topic should be told by the similarities and differences of exhibits. The benefits of AS within the virtual museum are:

- Spatially separated exhibits can be compared along the differences and similiarities.
- The comparison is presented within a content-related and semantically coherent story.
- Presented content is adapted to the users' interests.
- The story pattern is adapted to the users' preferences.

The challenge is to create a seamless chain of events while adapting the underlying causal structure to the user's preferences. The user interacts through individual interactions and thus shaping the story within a frame. The proposed museum application should function with realtime constraints similar to the systems presented in [RSWA09, HSWA10, LA07].

5.1. Classifying the User

In *IDtension* and *Defacto* there is a tight relationship between agent manager, used to simulate characters and the drama manager, used to dynamically generate the plot. For interactive drama the existence of non-player characters is necessary, but for the purpose of knowledge transfer in cultural heritage context we focus on the narrative not emerged from character interactions but from user interactions. Therefore, the user is classified as an archetype according to their input. Their decisions shape a character model which influences the genre recommendations.

Important dimensions to characterise the user are the archetypes, developed by the psychologist Jung [Jun11], refering to role prototypes. Jung reveals 12 different archetypes: outlaw, jester, lover, caregiver, everyman, innocent, ruler, sage, magician, hero, creator and the explorer. These archetypes are used to proceed a story. We recommend to harness all archetypes, because the user's personality is constructed by several of them. The user engages by interaction therefore we suggest also to use metrics characterising players of computer games: explorer, socialiser, killer and achiever, as described by Bartle [Bar96]. We also suggest to add museum visitor describing metrics to the character model: explorer, facilitator, experience seeker, professional/hobbyist and recharger, as described by [Fal09].

5.2. Adaptation of Genres

Patterns cluster together to uniquely define genres. We choose Aristotelian genres and subgenres as well as contemporary subgenres that seem promising for AS in the context of cultural heritage because they suit to convey information but are contemporary entertaining at the same time. We will focus on drama and epic, where we identified the subgenres tragedy, comedy and tragicomedy respectively short story, biography and novel. Novel contains Aristotelian and contemporary subgenres of adventure, education, fantasy, romance, historical, horror, crime and science-fiction, see Figure 1.

As the audience learns from stories how their social environment is structured, genres define certain sections of this environment. They have their own set of rules, that are derived from the human need. These rules form a skeleton of a genre story; they define which archetypes will be needed and which events should occur. It should also be defined which elements can be changed without harming the story's core.

As we want to increase the immersion of linked information units within the story, we plan to employ only stylistic bonds rather than complete, stereotypistic plots, e.g. of an adventure. On the fly adaptations should happen within certain boundaries to present feedback to the user about their rating. The boundaries should prevent a harm to the basic story structure.

5.3. Interaction of Rules and Data

A major part of the generated stories are story elements. A story element is a part of a former exhibit or background information, that is interlinked with other generic entities like Location, Person, or Topic, as depicted in Figure 2. The idea is to construct story elements by exploiting the links between known entities and the data available about the user in the UM. Thereby, possible subsequent story elements that continue a currently told story do not necessarily need to be connected in the first place [LA07]; it is part of a personalised experience that certain story elements emerge, based on similarities or differences of involved entities.

All relevant entities are generated in a Named Entity

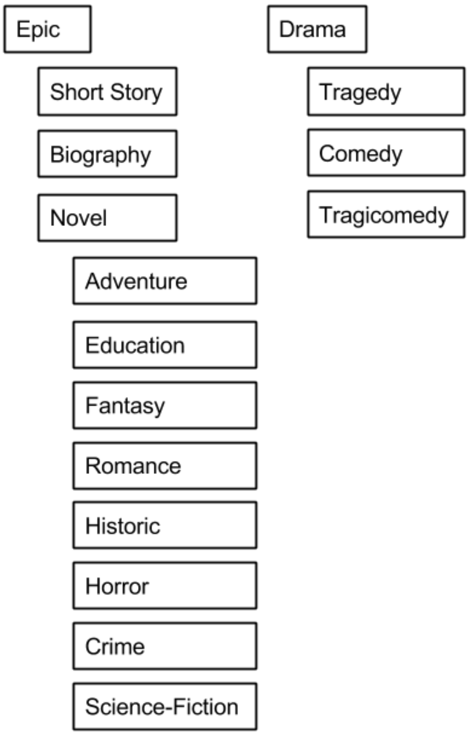

Figure 1: *Genres and subgenres used for AS.*

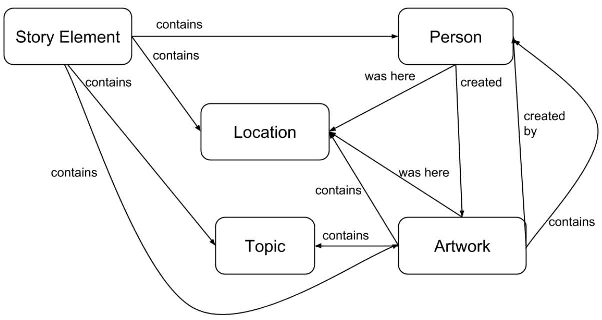

Figure 2: *Relations of story element to entities.*

Recognition process, which analyses the natural language input texts and identifies certain parts uniquely. This is exactly where the latest trend in Linked Data could be of use: Some solutions not only identify named entities, but they also provide suitable identifiers for these entities within the Linked Data cloud. This is considered to be the prerequisite of the entire approach.

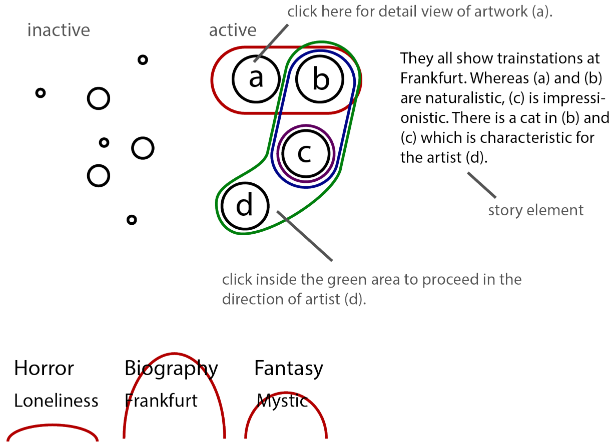

Figure 3: *Schematic graphical user interface for AS in a virtual museum.*

5.4. User Interface and Interaction Design

An avatar within the graphical user interface, such as the anchorman in [DGL*08], might fosters the impression of a one-sided conversation, or monologuing. The user evaluation in [DGL*08] reveals that the users refused such an anchorman in preference of a serious, more detached method for retrieving cultural heritage information.

As Murtaugh suggests, interactive stories are best told by user interaction [Mur96], therefore we recommend to focus on the content itself and let the user directly interact with it. In Figure 3 a schematic graphical user interface shows how the relation of exhibits and persons, the artefacts, that are relevant to the current story element could be presented. Each relation of the active artefacts, if demonstrating a similarity or difference, is contained in the story element text. Possible successors are presented to the user in different sizes according to their relevance. The genre adaptation is separated from the content adaptation to avoid multiple perspectives on the same content. On the bottom topic tags of the active story elements that are belonging to different genres are presented. The user rates how strong the genre should be represented. We assume, that it is a matter of interaction design to not let the rating disrupt the immersion of the story. The decision is stored in the UM. If the user selects the next story element from the inactive recommendations the story proceeds with the selected content in the prefered genre mix and the decision is stored in the UM as well. Now the genre keywords switch to represent the active story elements content, the high rated genre types maintain, whereas the low rated genre types are switched with new genre recommendations.

Both recommendations, content-related and genre-related, are based on the evidence stored in the UM. Highly-rated genres are preferred as well as content similar to the already selected content. To prevent isolation prob-

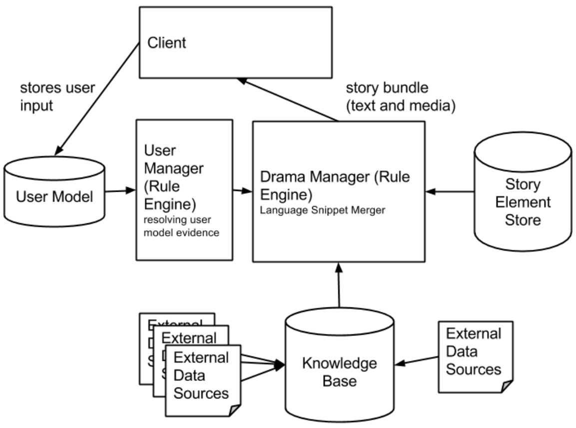

Figure 4: *Hypothetical architecture.*

lems the UM of other users are harnessed for correlation tests to provide collaborative recommendations. We also recommend to provide serendipity fostering recommendation mechanics. In comparison to IS the AS approach focuses not only on short term content recommendation, but also on long term content recommendation and genre recommendation. Szilas recommended a participatory design, to let the user rate stories to improve IS generation by machine learning [Szi05]. Therefore we suggest to let the user rate the whole chain of presented story elements at the end of the story. This data is used to verify if the genre and content adaptation should adapt more aggressively to move faster towards the user preferences or to adapt slowly to maintain what is pleasing to the user.

5.5. Hypothetical Architecture

The following hypothetical architecture outlines the several components we see in our concept. Generally, we distinguish between several kinds of data, and rules that operate on them. Accordingly, there are Data Providers and Rule Executors.

In Figure 4 the following components are sketched in a hypothetical architecture:

Knowledge Base - Data Provider The Knowledge Base forms a storage holding data loaded from external sources. It also offers capabilities to join data on reasonable points, and thus to take advantage from the multiplicity of interconnected data. In addition, the Knowledge Base streamlines the data structures for their respective use cases, thus it does not deliver paratexts directly to the user.

User Model - Data Provider The UM contains persistent data about the users. It includes expression of interests in certain kinds of genres, patterns, or topics.

User Manager - Data Provider and Rule Executer The User Manager fires rules on the UM in order to evaluate stored evidences. The resulting user preferences are provided for the Drama Manager.

Drama Manager - Rule Executer The Drama Manager finally produces a story, wired together from data about the user, provided from the User Manager, data about the collection, enriched with world knowledge from the Knowledge Base, and prepared natural language elements, archetypes and story structures, genre patterns, and character classifications. This is also the right place to follow the rules of certain storytelling patterns, like Propp's functions or Heros' Journey stages.

5.6. Benefits of Reactive Programming

The authors of this paper posit that many difficulties in implementing adaptive systems stem from an increased cost in development and testing time. Most traditional frameworks, like [Goo14, Ash14], require the developer to manually wire together the Model with the View. As updates to the Model are made, they must be "pushed" or the View is "notified" which creates further implementation friction. These problems are compounded as the Model changes and the View is no longer synchronised.

It is believed that the newly evolving trend of Reactive Programming [BCvC*13] will significantly reduce the aforementioned obstacles to cost-effective user interface development. *Reactive Programming* considers time as a data stream that continually changes all parameters that depend on it. The methodology of publish/subscribe and the Observer Pattern are approximations of Reactive Programming, but incomplete and error-prone [Bon13]. Furthermore, Reactive Programming promises scalability, uniformity and stability [MRO10].

Consider an example. Assume that this IS system categorises a visitor as described in Section 5.1. If the user visits the site for the first time, a default template is presented through which the visitor will identify himself as one or more of the possible roles. Through Reactive Programming it is possible to create a real-time change to the works presented and receive an asynchronous submission of updates if the local recommendations are insufficient. Within the context of the *Meteor* framework [Met14], it is possible to cache any evidence on a client-side database called *MiniMongo*. A lightweight recommender changes the content recommendations on the fly while the evidence is communicated to the server. The server, finally, publishes and removes any content specific to the user's roles. Important to note is the reactivity, from a lightweight recommender that operates on the user's machine without a remote call, and the server that asynchronously and automatically publishes new content.

6. Conclusion and Future Work

Existing interactive storytelling technology does not go far enough or is disconnected from valuable data sources. In this positioning paper we presented an initial idea towards adaptive storytelling. We suggested to extend interactive storytelling systems by adapting to user preferences in terms of preferred content and story genres for application in virtual museums. The main objective of the proposed approach is to present the similarities and differences of cultural heritage content like a museum guide in a physical museum.

Based on an extensive literature review of related research areas we proposed an interdisciplinary approach that combines storytelling with Linked Data. Furthermore we suggested how users should be classified in order to perform the adaptation. We gave an example of a schematical user interface and interaction design for adaptive storytelling in a virtual museum and sketched a hypothetical structure.

We see strong potential in this initial step, especially in its interdisciplinary nature. It is planed to develop a prototype application to evaluate the proposed approach. Future work includes ideas of participatory design. There is a demand for social interaction in virtual museums and we see a promising possibility to let a user influence a different user's story as the user can become any archetype. We want to explore how this can increase the immersion and therefore the memorability of the transferred knowledge.

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