Personalization of Virtual Coaching Applications using Procedural Modeling

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Abstract: Virtual coaching is an application area that allows individuals to improve existing skills or learn new ones; it ranges from simple textual tutoring tools to fully immersive 3D learning situations. The latter aim at improving the learning experience with realistic 3D environments. In highly individual training scenarios it can be beneficial to provide some level of personalization of the environment. This can be supported using procedural modeling that allows to easily modify shape, look and contents of an environment. We present the application of personalization using procedural modeling in learning applications in the project V2me. This project combines virtual and social networks to help senior citizens maintain and create meaningful relationships. We present a system that uses a procedurally generated ambient virtual coaching environment that can be adjusted by training subjects themselves or in collaboration. A small user experience study has been executed that gives first insight to the acceptance of such an approach.

1 INTRODUCTION

The usage of virtual coaching has greatly increased over the last few years, for various reasons. In many cases it augments or even replaces traditional coaching, in other instances it allows non-typical user groups to access coaching resources; but most importantly, the demand of individuals for improving their skill set has increased (Kozak et al., 1993; Rose et al., 2000). Virtual coaching applications have a considerable diversity, ranging from simple text-based online tools to immersive 3D environments that have been confirmed to increase various metrics relevant to the learning process and thus should be the preferred solution (Ijsselsteijn et al., 2006). However, the creation of immersive learning environments typically demands collaboration between designers of the 3D world that may lack knowledge of the learning process and creators of the coaching tools that might not be able to design 3D environments. Such collaborations increase costs and thus prevent wide-spread usage of immersive virtual coaching. Another important factor is acceptance of the system, which can be increased by providing personalization within the training environments, e.g. creating the appearance of their own premises. In this work we provide initial results on the acceptance of a personalization tool for virtual coaching system for elderly users.

Procedural modeling uses algorithms to automatically generate 3D models from a limited set of high-level instructions. While the initial investments in the tools may be higher, it allows generating further models easily. In coaching applications this means that a single procedural modeling tool allows the designers to easily and rapidly design new immersive learning environments, without requiring advanced knowledge in 3D modeling. It is easy to modify existing procedural environments, thus allowing a higher versatility and adaptation of the model according to the desires of the user as well as to the current learning situation.

V2me - Virtual Coach reaches out to me (V2me, 2013), is a collaborative European research project that aims at providing a coaching platform for older adults that allows them to create and maintain mean-

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ingful social relations. This improved social connectedness helps senior citizens to stay active and healthier for longer, as loneliness and lack of social activities is a major contributing factor to depression. Group therapies for teaching friendship skills have proven efficient in the past (Stevens et al., 2006). However, it is difficult and costly to provide such measures for a larger population. An alternative approach is virtual coaching that is supported by a limited set of technical systems and can be provided to a larger user group at decreased cost. This approach has been evaluated in V2me. It was selected as a case study to evaluate the advantages of the use of procedurally generated environments, which allow personalization of the content. These 3D environments are generated and personalized through a separate procedural scene editor, whose features are illustrated in this paper. We envision that procedural modeling systems can help designers and care takers to quickly create environments that closely resemble the actual environment of a system user. Therefore, a combined system is presented that allows swift creation and adaption of rooms through procedural modeling. In a second step those rooms can personalized by adding further items to the environment, adjusting their position and changing color and appearance of specific aspects.

In this paper we present the prototype tools that are created for this purpose and how they are applied in V2me. The system for procedural environment generation has been evaluated by social science experts in a mutual workshop with potential users. We present the initial findings of this study with a particular focus on the personalization aspects.

2 RELATED WORK

2.1 Virtual Coaching Applications

Virtual coaches have been in focus of research for several decades. Heylen et al. gave an overview of early examples (Heylen et al., 2009). The character "Karin" is a virtual receptionist residing behind the information desk at the lobby of the Virtual Music Center (VMC) - a virtual replica of the theatre in Enschede (Nijholt and Hulstijn, 2000). The dialogue skills of Karin are based on an earlier non-embodied dialogue system that interfaces to a database containing the information on the performances in the actual theatre. A dialogue system allowed people to query the information about performances and also to order tickets. Another example, INES, is an intelligent tutoring system primarily designed to help students practicing nursing tasks with a haptic device in a virtual environment (Heylen et al., 2005). INES takes into account elements of the student's character, his or her confidence level, and the difficulty of the task. It, moreover, gives appraisal of the student's actions.

Carcasso proposed a natural human computer interaction paradigm for persons with cognitive impairments such as Alzheimer's disease (Carrasco et al., 2008). The paradigm consists of a realistic virtual character, rendered on a television set, playing the role of a virtual personal assistant that shows reminders, notifications, and performs short dialogues with the user. In this paradigm, the television remote control is used as a return channel to capture the user's responses. Roelofsma and Sevim (Roelofsma and Sevim, 2012) suggested a framework for virtual coaching in changing lifestyles, including the domain of intrapersonal dilemmas that occur when people make choices that are in the best interest of themselves at the moment of choice, but not in the best interest of themselves in the long run. This framework is based on multiple selves' theory that proposes a self-perception of various personal roles, such as a planner and a doer, which might have conflicting intentions over time. Ortiz et al. performed an empirical study with older adults and avatars, showing that subjects follow instructions better, that they can understand the facial impressions of an avatar even when having cognitive impairments, and that interaction with an emotionally responsive avatar was regarded as pleasant (Ortiz et al., 2007). However, the presence had no perceptible influence on recall. They suggest that application of an avatar should depend closely on the specific task. In A^2E^2 (A^2E^2, 2013), virtual coaches are connected to several sensors, which include an activity and a movement sensor, as well as blood pressure and weight sensors. The Virtual Coach interacts with the elderly persons in real time in their home environment and motivates the elderly to a healthy lifestyle.

2.2 Procedural Modeling

A conventional 3D model consists of geometry data that describes the shape of objects and their pose (position + orientation) in a 3D scene. By contrast, a procedural model is a computer program that generates this geometry data on the fly when it is run. Thus, it describes the operations required to create an object. A procedural model can, therefore, describe a whole family of objects or scenes.

Procedural modeling is used in various kinds of applications. First and foremost, it has become essential for content creation for computer games and motion pictures. Here, huge landscapes and urban

structures are often needed, and with the ever-growing scale of such projects manual construction is becoming increasingly infeasible. Most notably here is Esri's City Engine (Esri, 2015), which is used to generate large cities and buildings through split grammars (Wonka et al., 2003; Müller et al., 2006; Thaller et al., 2013b; Zmugg et al., 2014).

As for coaching applications, it is important that the users remain interested in the system, leading to adaptation and personalization as important factors. Modifications can happen on two levels. First, the care givers may want to re-use existing environments and adapt them to provide the users with new content. And second, users may want to change parts of the displayed environment to their personal preferences. A procedural modeling system allows both: Changes can be made at any point of the generated scene without much effort. Changes of the environment can also happen fully automatically based on different aspects. For example, if there is a procedural model of a bedroom for two people, it can be automatically enlarged to fit for four people.

Procedural models are usually described in some sort of scripting language; but this makes the system not very accessible for non-expert users. Therefore, an interface without scripting is necessary. The modeling packages Houdini (Side Effects Software, 2015) and Grasshopper (McNeel and Associates, 2015) show a graph-based representation of the procedural model. This graph helps to understand how the model is built and what dependencies exist without showing the underlying code. In our system, whose theoretical foundations were initially presented by Thaller et al. (Thaller et al., 2013a), neither the code nor the underlying dataflow graph are shown to the user, but dependencies are illustrated by highlighting related parts in 3D. Furthermore, hierarchically arranged scenes can be traversed in an intuitive manner. Our system uses a dataflow graph only in the background, which is used to generate the necessary script code automatically. This happens completely transparent to the user.

3 V2me AND PERSONALIZED ENVIRONMENTS

V2me is a research project that provides a coaching platform for older adults that gives lessons to maintain or create meaningful relations. It is based on a specifically designed social network that reduces cognitive load during use. Simplified communication systems allow the users to interact with their peers and potential new friends through a virtual friendship enrichment course (Stevens, 2001). In order to increase the efficiency of these aspects, an immersive *Virtual Coach* – a 3D character that provides lessons, expert information and links to different aspects of the system functionality – resides in the apartments of the users. The virtual environment of this Virtual Coach should be adaptive to the current situations, both in regards of user input and expert presets that are stored in the system or updated from a central web service regularly. A major requirement for the created tools was that they have to be used by non-technical personnel to allow independent creation of lessons and environments. The system is modular and has three main components. The **Mobile Platform** is a portable tablet computer that is used independently by the participant. It provides the Virtual Coach functionality as text-and-audio representation and enables interaction with other users. The **Home Platform** is a large-screen PC. It communicates with the server to synchronize content and host the 3D representation of the Virtual Coach and environments. The **Web Platform** is a web-based engine that allows family and friends to communicate with network participants.

Figure 1: The Virtual Coach (source: (A^2E^2, 2013)) in a virtual environment created with the editor, which is displayed on the Home Platform.

3.1 The Home Platform

The Home Platform visualizes the content created from the procedural descriptions. The generated 3D environments are the "home" of the Virtual Coach. The Virtual Coach interacts with the user in the provided environments that can be, for example, a flat (see Figure 1), or a park. The procedural environments are generated with a separate piece of software, the *Content Editor*, which will be presented in the following Section 3.2.

The Home Platform is responsible for augmenting all the actions done on the mobile device. The Mobile Platform is able to trigger all animations defined for the environment in the editor. Facial and body animations and the text-to-speech engine of the Virtual Coach can also be triggered independently. Upon

completion of a task by the user, the Virtual Coach reacts with appropriate animations, such as clapping.

The Home Platform provides an immersive interaction environment for the users of the system. Instead of the small screen on the mobile device, the larger screen provides a more sophisticated form of interaction. This enables an engaging learning experience for the user that should result in increased participation, improved learning speed, uptake and recall.

3.2 The Content Editor

We utilize the procedural modeling approach in the Content Editor, which is used to generate environments for the Home Platform. This editor is based on the Generative Modeling Language GML (Havemann, 2005) and uses procedural techniques in various ways to create non-static content that can be personalized. These include procedural modeling of backdrops, procedural scene graphs, procedural object and camera animations, and personalization of parameters and objects.

In combination, these techniques can be used to generate 3D animated stories that can be personalized for individual persons and used to guide, help, and entertain the target group. This system is adapted from one Zmugg et al. presented in the Cultural Heritage domain (Zmugg et al., 2012a; Zmugg et al., 2012b). The different steps for the generation of procedural environments are discussed in the next sections. For V2me, we have created only a pilot prototype of a procedural scene editor; as in many research projects, much remains to be done to be production ready, but the feedback we got confirmed that the overall approach is understood and appreciated by our pilot scene production team (see Section 4).

3.2.1 Modeling of Backdrops

Backdrops are the environment where the Virtual Coach and other objects are positioned in (see the flat in Figure 1). Backdrops can be generated interactively without any need of scripting. The parametric system is based on a set of basic modeling operations and procedural assets. The modeling operations are inspired by split grammars and feature several operations to partition existing shapes into smaller pieces. Modeling usually proceeds in a coarse to fine manner, meaning that an initial shape is sequentially refined to achieve the desired result. To remain concise, the modeling operations are not explained individually in this paper. For a detailed explanation of the modeling operations we refer to (Zmugg et al., 2012a).

Procedural assets are ready-made parametric models. Our system features several libraries which include, for example, windows (like in (Thaller et al., 2013c)), arches, or other architectural elements. These models are, however, not static, instead they provide parameters to approximate a wide range of different elements. They, furthermore, adapt their size dependent on the shape they are inserted into. An example demonstrating procedural modeling operations and procedural assets is shown in Figure 2.

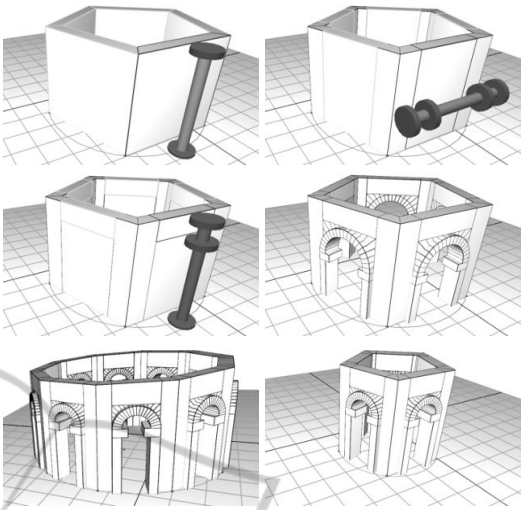

Figure 2: Selected steps from creating a circular building using the procedural modeling engine. First and second row: The the wall is subdivided into parts to define the space for the parametric arch. Bottom row: Decisions made at the beginning (number of sides, radius) can still be changed later on, which allows change and personalization of procedural models (Zmugg et al., 2012b).

3.2.2 Modeling the Scene Hierarchy

After generating and texturing the background, elements can be positioned in it. We use the concept of procedural scene graphs, which was proposed in previous work (Zmugg et al., 2012b). A scene graph is a hierarchical structure to describe dependencies between objects in environments. Every object in the scene is represented by a node in the scene graph. Each node (except for the root node) has one parent and an arbitrary number of children. The parent-child relation propagates all changes made to the parent to all of its descendants. Technically, every node features a 3D pose transformation (4×3 matrix) that affects all its children. As a simple example, imagine a vase that is placed on top of a table. Without a scene graph, moving the table does not move the vase, and vice versa. By using a scene graph, the node representing the vase can be made a child of the node representing the table, and, therefore, moving the table moves the vase too, while the vase, as the child of the

Figure 3: A camera flight on the Home Platform visualized as a sequence of images. From the view on the Virtual Coach the camera moves to a close-up view on the tablet placed on the table.

table, can still be freely moved on the table.

The scene graph can be manipulated by the user through 3D widgets. This way, e.g. furniture objects, collected from SketchUp 3D Warehouse (Trimble Navigation Ltd, 2015), can be arranged in the 3D scene. Technically speaking, the 3D model of the Virtual Coach is part of the scene graph too.

3.2.3 Animating the Scene

Finally, animations can be defined for all the objects arranged within the scene. To achieve animations, key frames storing position and orientation can be defined for any object in the scene graph. During animation, these key frames are interpolated, and can be assigned to specific time slots. For these time slots specific avatar animations can be set too. As an example, the walking animation of the avatar can be activated while the scene graph node, which contains the avatar, moves in the scene. The view on the scene during these animations is controlled via camera objects that can also be placed on scene graph nodes. By animating camera objects, it is easy to produce camera view transitions (see Figure 3). The time slots can be queued and also arranged in parallel to create simultaneous animation time lines. The environments, together with the defined animation time lines, can be executed on demand on the Home Platform.

3.2.4 Personalization of the Scene

The *curator mode* for this system was introduced in previous work (Zmugg et al., 2012b) in a Cultural Heritage context. It can be utilized within an Ambient Assisted Living context in a different, but related way. The curator mode was designed to provide a museum curator with a way to make final changes to the scene layout. The scene is defined through a scene template

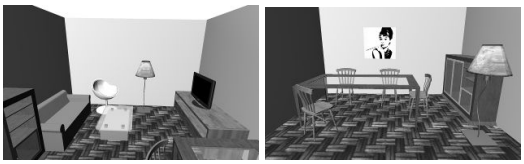

Figure 4: Different ways for furniture placement in a living room realized through use of the personalization mode.

beforehand. This template encodes everything the curator is allowed to change and possibilities are deliberately limited so that they are shielded from accidentally doing harm to the scene, and to work in a more targeted and efficient way.

The situation within the V2me system is similar. Caregivers can design environments and the animated stories within them. Afterwards, the elderly people could use this so-called *personalization mode* to personalize the environment. For instance, it is possible to define within the template which parameters can be edited by the elderly users. Take, for example, the model from Figure 2. It may be allowed to change the radius of this model freely, but the position and the number of segments may be fixed or constrained. Another feature are the so-called *drop targets*, which are positions for additional content. For example, around a table a set of six drop targets with restricted movement capabilities can be placed. The user can then decide how many (up to six), and which chairs they want to place around the table. This way, users can create entirely different environments based on a single template, by re-arranging objects and even placing new objects in the scene, such as pictures on a wall (see Figure 4). For the animations, which tell a story through the procedural environment, to remain the same, the configuration options of story-related animations and objects are not available or are restricted.

3.3 Workflow of Creating and Personalizing an Environment

To give a concrete example we will briefly outline the workflow (see Figure 5) of generating a personalized environment using the tools presented. At first, the basic apartment is created using procedural modeling. This step can be performed either by a designer or by a care taker that has been trained for this task. This model can then be stored as a template and be further used to create new apartments even quicker. To create such models knowledge of the modeling tool functionality is required.

The next steps are to be performed by a care taker that has knowledge of the user's environment. First, different details are added to the scene. The next step is adding furniture objects to the scene, such as chairs,

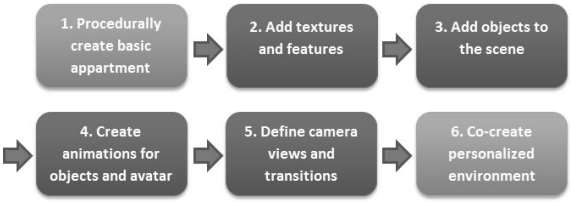

Figure 5: Workflow of creating and personalizing an environment.

tables, or plants. The 3D model of the Virtual Coach is also placed in the scene. Afterwards, animations of the before placed objects are defined in the scene. In this step, the care taker will define where the avatar should reside and perform most of his actions. This is useful, e.g. to have the avatar appear in favorite places of the user. This increases the feeling of immersion for the user. Lastly, the care taker will define the camera views and transitions to highlight specific parts of the scene, or the actions and mimic of the avatar.

The last step is the personalization of the environment that happens in a co-creation step between user and care taker in the personalization mode of the system. Here, personal items can be placed or wrong assumptions about preferences can be redeemed. The environment is visible to both user and care taker and changes are immediately represented. The final result is an environment that closely approximates the actual surroundings without requiring the intervention of seasoned designers in most steps of the process.

4 EVALUATION

The concept for friendship coaching within V2me has been adapted throughout the runtime of the project (Muuraiskangas et al., 2012). At the end of the project, a long term study was conducted with several users in the Netherlands. In this scope, we wanted to test various aspects of personalization of the system and how procedural modeling can contribute to this task. Interviews were conducted with all participants, covering the aspects on how the quality of a procedurally modeled environment is regarded, what elements are required in the environment, and how the environment can be improved.

4.1 Study Design

Three women and four men, ranging from 64 to 77 years in age, participated in the long term evaluation of the V2me system. The subjects who participated were living independently and alone. Subjects were selected based on their score on the De Jong Gierveld Loneliness Scale (de Jong Gierveld and van Tilburg, 2006) (scores should be moderate to high) and on openness to technology (scores should be high). Subjects received an instruction session after the V2me system was installed in their homes. This system setup included a predefined apartment environment and stories featuring the Virtual Coach. The functionalities of the personalization mode itself have not been directly part of this study. The predefined setup was used to assess the interest of the users in changing and personalizing the environment, hence using the personalization mode in the future.

The loneliness intervention lasted for two months. Afterwards, they received the loneliness and openness to technology questionnaires again, and a semi-structured interview was held about their experiences with the Home Platform. In this interview they were asked questions like what they thought of the Home Platform and the interior of the dwelling, and what they would like to see changed, if they could change it. Because the participants are usually not used to terms like procedural modeling, these questions had to be designed properly to assess their interest in personalization features.

4.2 Interview Results

Regarding the quality of procedurally modeled environments, each participant showed to have their own preferences for this. One subject mentioned that *"Its very beautiful, very well made. (...) I like the interior a lot."* and *"I love how the parquet has been made"*. Answering on the question what elements are missing from the virtual environment the responses varied from *"the house lacks a lot of stuff"* to *"it is too crowded"*. Asking how the environment can be improved, some participants would have preferred the coach to reside in a more comfortable environment. They would *"add a couch, a little lamp, so he can sit down and read."* or conclude that *"he needs a stereo set, a TV, and a leather couch."* Or *"he could use a fridge or a TV. Or a stove in his kitchen."* Most participants would have preferred their coach to have some company, including a female housemate, or pets. Finally one participant wanted more interactive elements in the environment, such as *"a TV that shows clips from Youtube or news items."*.

4.3 Discussion

The users were generally happy with the visual quality of the procedurally generated environment and the existing objects added to it. Therefore, we can assume that similar environments can be equally well

received. Preference plays a huge part in the question how comprehensive the provided environment was perceived. Some users found it to be limited, and would have preferred additional personal items for the coach. Providing more objects was the most common suggestion for improvement in the future. Here it is important to create an interface that enables to access this variety in a simple fashion. Additionally, some more interaction for the coach should be added, such as companions in the environment. This is more difficult to accomplish, however the required animations and models can also be procedurally generated. The final aspect is interactivity, whereas objects should link to additional services, such as Youtube or Wikipedia. Again, this is interesting to pursue in a future work by creating a library of web services that can be linked to objects in the environment.

All in all, the results indicate that every user has their own specific preferences for the design of the environments of the Home Platform, so personalization is a desirable feature for virtual coaching systems.

5 CONCLUSION

We have presented a system which is capable of generating personalizeable environments for elderly people within coaching applications that rely on 3D content. Procedural modeling techniques are utilized to generate environments, animations and camera flights within an editor, which is designed to be accessible for non-expert users; so programming is not necessary to use it. This editor is used within the V2me system to generate environments in which the Virtual Coach is presented and interacts with the user. All defined animations and camera flights can be triggered by actions of the user. This in combination with lessons that are designed by professional psychologists is used to tell stories and give tasks to motivate people to get involved in social activities again. After all, the ultimate goal of the project is to stimulate richer real-life social experiences.

All elements positioned in the environments created by our editor can be repositioned and extended at any time. In a separate personalization mode, the configuration options can be limited, so elderly users gain more control and are shielded from doing harm by not accessing certain parameters. The results from the user study explained in Section 4 show that there is a big interest in personalization of environments. The answers of the participants indicate that a single environment is not sufficient because the priorities and preferences of the participants differ vastly. This shows that procedural modeling needs to be facilitated so that the wishes of elderly people for virtual coaching systems can be fulfilled with ease.

First results have shown that our approach is a promising new ICT-based method for bringing care to the homes of the elderly people in a socially meaningful way. Especially the flexibility and use of the generic aspects of the content editor proved to be promising for care givers and professionals.

5.1 Limitations and Future Work

The system has not been adapted for usage by the elderly end users of V2me yet. For the current training applications it was more suitable to have a system that provides developers of training systems with tools that allow them to create immersive environments. For this a rich set of functions have been developed in collaboration with social scientists. The environments for the user study were created by this team. However, with a limited amount of training they should be able to create their own environments. The system is prepared for the environment personalization. Modifications should be accessible for all users in an intuitive way. The focus of the prototype up until now was on functionality rather than usability. Increasing the usability of the system and make it accessible for elderly user groups is the most important step in our future work. We anticipate stimulating psychological effects if the user can influence the surroundings of the Virtual Coach with no assistance.

Additional improvements and future work for the prototype include a more realistic rendering and a wider range of possible objects. We currently work on functions to design also the avatar animations procedurally, so that the animations of the Virtual Coach can be dynamically adapted, e.g., controlling the level of smiling, or specifying animations that adapt to different chair and table heights. This is indispensable for more interesting plots and stories.

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