Coffee Champion

Games with a Purpose for Medical Rehabilitation with the Use of the SHaRe Device

Technical University of Munich
Design and Implementation of Business Games
Munich, Germany

Jakob Raith, Maria Katarina Schulze, Technical University of Munich
on behalf of the entire development team

Abstract—This paper aims to describe a project by students of the Technical University of Munich in which a game was developed with the purpose of aiding medical rehabilitation of patients with hand trauma. It will make a detailed description of the device itself, as well as the game and make an assessment about the usability of both the SHaRe device and the game for future development.

Keywords—games with a purpose, medical rehabilitation, game development

1 Realization

We, the development team, were tasked with creating a game with the purpose of demonstrating the SHaRe device's capabilities and aiding its process of medical rehabilitation. Over the course of a semester, we met regularly with our instructors to plan the game from its conception to the completion of its first prototype. It is important to note, that due to the duration of the project as a single semester course, we only developed an early prototype which includes all of the main features, but is yet unfinished and subject to future development.

2 SHaRe Device

The SHaRe device, or the System for Hand Rehabilitation in Dexterous Manipulation of Daily Objects, was developed by a researching group of the University of Porto in order to help patients with hand trauma regain manual dexterity. Its main features include a force sensor, a gyroscope, an accelerometer and a light detector. The controller's shape resembles that of a flattened cone and as such fits neatly into the human hand. The handle piece is comprised of two parts which, when pressed together, detect the force applied to it. The core piece, hidden by both halves of the plastic handle, then detects its own orientation and its position in a Cartesian coordinate system. Furthermore, the controller is able to detect via its light sensor at the bottom of the device, whether it is resting on a surface or not. For further reference, see the projects' homepage (https://remotelab.fe.up.pt/instrumented_devices/shareDetails.php).

3 Technical Documentation of Coffee Champion

3.1 Gameplay Description

Coffee Champion is a simulation game in which the player takes on the role of a barista in a coffee shop and prepares beverages for their customer. The following description of gameplay elements is applicable to the finished game. In the developed prototype only, the core mechanics are realized. The last part of this segment will list the features that made it into the prototype. The game opens with the scene. From a first-person perspective, the player is presented with their coffee shop environment and is confronted with their first order. The order is a randomly selected beverage from a list of predetermined beverages: the menu. The order will be explained to the player via visual and auditory cues, then the player will be asked to prepare the beverage themselves. The order will then be displayed at the side of the screen and visible for the duration of preparation. The camera moves to the far left of the preparation counter and, depending on which recipe was selected, different actions need to be performed to complete an order. The following steps could be presented to the player (not necessarily in chronological sequence):

1. Selecting a Cup
   1.1. A turning tablet is shown at the left-hand side of the screen and presents three different cup types; circling continuously.
   1.2. Player picks up controller when the desired cup type is in the forefront
   1.3. Cup type in the front gets selected and highlighted
   1.4. The player squeezes the controller to confirm theirselection
   1.5. If the selection is wrong, the player will receive negative points towards their overall score. After failed selection, re-selection will initiate and proceed from point 1.1 on
   1.6. If the selection was correct, the in-game representation of the controller will shift from the SHaRe device to the selected cup

2. Squeezing
   2.1. Game indicates visually that a Squeezing action needs to be performed
   2.2. Player picks up controller
   2.3. Depending on the recipe, controller may need to be flipped upside down.
   2.4. Player applies a specific amount of force for a specific amount of time to the SHaRe device.
   2.5. Player puts the controller down.
   2.6. Score will be added or subtracted in accordance with accuracy and timing.

3. Pouring
    3.1. Game indicates visually that a Pouring action needs to be performed
    3.2. Player picks up controller
    3.3. Controller is tilted into direction one wants to pour. Tilting has to be maintained for certain amount of time
    3.4. Player rotates controller back into upright position
    3.5. Player puts down controller
    3.6. Points will be added or subtracted to score in accordance to accuracy.

4. Shaking
    4.1. Game indicates visually that a Shaking action needs to be performed
    4.2. Player picks up controller
    4.3. Player shakes controller rapidly up and down
    4.4. Game indicates visually that Player needs to cease Shaking motion
    4.5. Player puts controller down
    4.6. Points will be added or subtracted in accordance to timing.

    A progress bar tracks the stage of completion of the individual steps. Once every step is completed, the order is finished. A final screen will inform the player of their individual scoring in each task as well as their final score. This marks the end of a level.

3.2 Implementation

The prototype was developed with Unity and as such uses scripts in the C#-programming language. The Unity game engine utilizes a so called "Entity Component System". This software engineering design pattern is common in game development. Components are constructs to store data and entities as objects in the game that have list of components attached. Systems in the Unity engine, such as a physics engine or a system for artificial intelligence, operate on these components and manipulate the stored data [1]. As the embedded systems of the Unity engine access and manipulate the developed entities and components of the prototype and do not adhere to conventional inheritance structures used in object-oriented programming, it is not feasible to create a class diagram for the prototype. The following will describe the main parts and systems of the prototype in greater detail.

3.2.1 Share Actions

A ShareAction is the part of the game with the greatest detail richness, as one object represents one singular movement defined for patient interaction. The ShareAction script is the base class for all interactions with the SHaRe device which inherits from Unity's MonoBehaviour class. The interactions are defined in classes that inherit from ShareAction. There is a separate class for each movement and thus the system can be easily expanded. ShareActions define functions for entering and exiting an action as well as a call to MonoBehaviour's Update function for rendering tasks.

3.2.2 Ingredients

An Ingredient represents one step in the game the player needs to perform. It is trackable and visible via the UI. The Ingredient script has a list of ShareAction objects and adds information on current progress of each step as well as displayed information while the player is performing.

3.2.3 Recipe

The Recipe script was implemented to create a data structure which adds different levels and other combinations of movements to the game. It collects a given number of ingredients and accesses the ShareAction objects in the ingredients. It manages the lists of actions and calculates the score for completed or failed actions.

3.2.4 Recipe Manager

The main managing system in the game is a state machine in the RecipeManager script. As each ShareAction can be translated into a certain state in which the game resides during the time of the action, the RecipeManager can access the list of ShareAction objects of a given Recipe and iterate through that list as the player progresses through the movements. The state machine is implemented in a way that makes it easy to extend the repertoire of available recipes. The RecipeManager also serves as the main game state manager and is the first script to be executed once the game scene is loaded. After loading the demo recipe for the prototype, it will commence to start the gameplay flow.

3.2.5 User Interface

Another focus area of the game was to give players accurate feedback and audiovisual cues while playing. Different user interface entities were implemented to handle the timing and highlighting of important cues and instructions. These entities include a progress bar, tracking the player's progress through the recipe and an instruction window that automatically translates the recipe into written instructions. The instructions are checked and crossed out when completed and are continuously visible throughout the preparation process. Furthermore, the score is tracked within the user interface during each step.

3.2.6 Music and Sound Effects

The RecipeManager also has access to the MusicManager and SoundEffectManager. The former manages the playback of music for varied but pleasant background music as a continuous loop. The SoundEffectManager provides functions to play and stop all the necessary audio cues of various in-game actions, looped for the duration the players actions.

3.2.7 Translation

In order to provide text output in multiple languages, a dictionary data structure was utilized to create language files for English, Portuguese and German. The Translation script is accessed whenever written output is needed in the user interface.

4 Assessment

The goal of Coffee Champion is to help medical patients to regain hand dexterity. In collaboration with the University of Porto, the research group, who created the SHaRe device, and we, the development team, decided upon a list of set movements which we deemed beneficial to potential patients. Their realization can be viewed in the game prototype. We focused on hand gestures most commonly associated with everyday life tasks, as it was the University of Porto's team main concern. Studies of the Nintendo Wii system show, that not only do patients think the inclusion of video games made therapy more enjoyable, but comparable if not better than conventional therapy methods [2]. A similar study with the Kinect system resulted in enhanced physical performance its patients [3]. with Introducing video games as a therapeutic method gives patients a much-needed sense of accomplishment, made both visible and tangible by means of game mechanics and thus instilling an intrinsic motivation in the player.

Intrinsic motivation is key for optimal outcomes. A major concern of any rehabilitation therapy is whether its patients get enough exercise, whether they meet their daily "“dosage” of movements required to induce […] behavioral improvement" [3]. Conventional therapy methods lack engagement and become repetitive after a while and thus decreasing the patients' motivation to perform given task. Since the positive effects of video games utilized in physical therapy became more widely known and accepted, most of these games have been constructed by those working in the medical field, whose main concern is functionality over enjoyability [4]. Thus, we conclude that having those in charge, who are trained in the art of producing engaging, replayable games, is a major benefit to both patients and medical staff.

5 Results

5.1 Summary

Coffee Champion is a prototype for a project that requires a grander scale than a mere semester-long student-project. The groundwork has been laid for future developers, all that it needs is dedication for completion. We, the development team, tried our best to make our prototype as extensive as possible, incorporating every single planned feature and design but not every asset and code snipped made it into the final product. Coffee Champion is, however, a presentable prototype for the functionality of the SHaRe devices capabilities and its use as therapeutical as a game controller.

5.2 Future Prospects

Coffee Champion is, despite being a fully functional prototype, subject to further development and improvements. Ideally, the project will be continued by a successor, a single student or a group, to improve the game and expand upon it. We think our approach to the game is straightforward to those trained in the field of engineering games, however, as for the SHaRe device, we compiled a list of optimization opportunities for both the device itself and its usage as future developers might encounter the same issues we did.

The light sensor at the bottom of the device presented itself difficult to work with. It is placed very close to the edge of the device's casing. Due to the transparency of the material, a lot of false positives are measured by the sensor unless placed upon a relatively bright surface. A simple re-positioning of the sensor to an area less luminate would improve the quality of the sensor data significantly. Preferable to that would be exchanging the light for an infrared sensor as its measurements are not dependent on environmental lighting conditions. Coffee Champion refrained from using the inbuilt light sensor for that reason. The implementation detects picking up and putting down movement of the cup solely through the accelerometer. That makes it necessary, however, to calibrate the device and its accelerometer before starting the game.

6 Acknowledgment

We would like to thank the research team at University of Porto for giving us the opportunity of working with them in an international collaboration on a project of current scientific interest. A special thanks goes to Rafael Tavares, who volunteered to visit us in Germany to not only deliver a prototype of the SHaRe device for us to use but to help with the incorporation of the device as a controller for our game.

We would furthermore like to thank our instructor Matthias Utesch for providing us with a learning environment in which we could manage a group of 15 independently and emulate working a real-world software development team and all the challenges that go with it.

7 References

[1] Klutzershy (2013), Understanding Component-Entity-Systems, https://www.gamedev.net/articles/programming/general-and-gameplay-programming/understanding-component-entity-systems-r3013, (02/23/2018)

[2] Joo LY, Yin TS, Xu D, et al. (2010) A feasibility study using interactive commercial off-the-shelf computer gaming in upper limb rehabilitation in patients after stroke. J Rehabil Med. 2010;42:437–441.

[3] Yeh S-H, Hwang W-Y, Huang T-C, Liu W-K, Chen Y-T, Hung Y-P. (2012) A study for the application of body sensing in assisted rehabilitation training. In Proceedings of IEEE International Symposium on Computer, Consumer and Control (IS3C). Taichung, Taiwan. 2012:922–925. doi:10.1109/IS3C.2012.240.

[4] Flores, Eletha & Tobon, Gabriel & Cavallaro, Ettore & I. Cavallaro, Francesca & Perry, Joel & Keller, Thierry. (2008). Improving patient motivation in game development for motor deficit rehabilitation. Proceedings of the 2008 International Conference on Advances in Computer Entertainment Technology, ACE 2008. 381-384. 10.1145/1501750.1501839.

8 Authors

Jakob Raith and **Maria Katarina Schulze** are Bachelor students in Informatics: Game Engineering at the Technical University of Munich, Arcisstraße 21, 089 28901, Munich, Germany.