WatchSim

A watch repair simulator tool

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Abstract — There is no question that watch repair is a delicate and precise art but what is not always obvious is that this craft is also a science. Like surgery, it can be taught by the same means as any other modern coordination-intensive activity - through repetition, study, and reinforcement of underlying principles. However, the trade of watchmaking has been slow to adopt modern educational technology, which has had a negative impact on attracting young new tradespeople to the craft and training the increasingly tech-minded younger generation.

WatchSim was created to address the lack of educational technology in the field and promote the use of simple, educational tools to overcome some of the pedagogical hurdles with which the watch repair industry currently contends. WatchSim is a simulator that allows the user to disassemble and reassemble a basic pocket watch, just as would be done in a normal watch servicing. Along the way the user has the opportunity to learn what each part inside the watch is and its purpose inside the timepiece, in addition to part placement and general watch structures.

1 INTRODUCTION

The watch repair field is currently plagued by many educational issues: there is almost no technology used for instructional purposes, the majority of training is performed apprenticeship-style, and there is little consistency in the quality or structure of education outside of a few small programs.

1.1 Absence of technology

A typical watchmaker learns by doing - disassembling and reassembling watches until the concepts become clear. This is supplemented by light reading of reference manuals and low levels of guidance and observation. Due to the number of small and delicate parts, repetition of such exercises is time consuming and makes learning groundwork concepts, such as part names and placement, a long process. By introducing digital tools such as WatchSim, basic concepts become more easy to master through repetition without losing much of the interactive, hands-on learning provided by holding the timepiece in hand.

1.2 Pitfalls of apprenticeships

Learning to be a watchmaker outside of formal or informal apprenticeship training is exceedingly rare. The typical new watchmaker learns all he or she knows by working one on one with a master watchmaker. This apprenticeship-style transfer of knowledge presents three significant issues: it is not conducive to instructing multiple pupils at once, knowledge transfer over the course of the apprenticeship is often incomplete, and many masters never teach any new students. Consequently, knowledge is lost in the field every day as older watchmakers retire at a faster rate than new watchmakers are brought into the industry (Wright, 2013).

1.3 Little consistency amongst formal training programs

While formal training programs for watch repair do exist they are often long, arduous, and inconveniently located (Esslinger, 2017). Several schools or small programs exist in the United States and beyond and many are free or low cost due to the demand for new watchmakers. However, many of these programs are sponsored by parent organizations that do not have practices consistent with one another and the material is not always formally structured (Brandt, 2014).

For example, there are about three two-year programs in the United States sponsored by the American Watchmakers and Clockmakers Institute that are highly intensive where participants attend classes for about eight hours a day. There are also many other programs that are two days to two weeks long where you learn one specific skill (e.g. learning how to properly oil a jewel), but these classes do not require any previous knowledge of other repairs and are not held to any national standards so participants in these classes often leave with partial knowledge.

1.4 Addressing the consequences

Strict adherence to apprenticeship pedagogical structures and a lack of technology to formalize and expedite education has lead to a “birth rate” of new watchmakers being significantly lower than the retirement rate of older watchmakers, leaving employment gaps in the field (Ogbeifun, 2011). Without remediation, watchmaking (which already has the “dying art” moniker) will continue to fade in the coming decades. Through the use of technology the industry can appeal to more digitally-savvy young people and expedite training processes across the board.

1.5 Project objectives

The goal in creating WatchSim was to develop a proof of concept for an entry-level educational tool that can help users become familiar with the most structurally important watch components and to practice manipulating them without having to sit at a workbench for hours with screwdrivers and magnifying lenses. This digital simulator is less time consuming than traditional repair practice, but also provides to-scale part renders and real-time instructions for a portable, instructional, and interactive experience.

2 RELATED WORK

There are few educational tools available to watchmakers, so there is no other work directly related to that which is addressed by this project. However, there has been a large quantity of research done on simulators and their effect on education where simulators have shown to be efficacious in producing higher learning outcomes for students in other industries that are typically taught in a hands-on fashion.

2.1 Simulations in the medical sector

Many medical and nursing schools are turning to digital simulation labs for learning basic anatomy instead of using cadaver dissection. For example, a recent study was performed where sophomore and junior year nursing students were provided with a simulator that allowed them to virtually place a feeding tube in a patient. In comparison to the traditional method of using a dummy for practice 86% of the students found that the simulator provided them with a more accurate learning experience and left them feeling more prepared than the traditional approach (Aebersold et al., 2018).

Additionally, a different study with 16 surgical residents had half of the participants study in traditional means for a surgery while the experimental portion of the group participated in a simulator where they could virtually perform the surgery. When it came time to perform the real surgery it was found that the residents who had used the simulator to prepare had on average 30% faster completion times and 6 times fewer errors than the control group (Seymour et al., 2002).

2.1.1 Interactive medical atlases

Studies on interactive atlases have also yielded positive results, such as the 2015 study on an interactive virtual reality anatomy program that provided students with an opportunity to see the different layers of the human body on a screen with labeled parts (Guy et al., 2015). This program was used in contrast to the standard practice of dissecting cadavers to learn the body parts. Students found the digital approach to have high utility and usability.

Another interactive anatomy atlas played on the idea of a “magic mirror.” 7 clinicians and 72 students were given the opportunity to try out a mirror that provides an augmented reality overlay of the user that shows them their own body but allows them to see each part labeled. The mirror also let the user see an exploded view of their body that is separated into layers with skin, muscles, bones, and internal organs. All of the parts are labeled and the functionality of each component is explained. The project was met with a 92% approval rating in overall learning experience by both clinicians and students (Ma et al., 2016).

2.2 Simulators in aviation

Comparable positive results were found in a study examining the effectiveness of flight simulators for pilots. Trainees who used a flight simulator to prepare had improved flight performance and they tended to learn and retain new information better during real training flights. It was also discovered that the trainees who used the simulator had lower physiological stress levels during their real training flights, based off of visual metrics and heart rate (Magnusson, 2009).

2.3 Relevance of related work

While not directly related to the watch industry, all of the studies explored are related to fields with similar learning goals and techniques (namely memorization and procedural repetition to learn a process and its components). There is support that simulators have a positive impact on both students' real life performance on a task as well as their ability to learn more effectively while actually performing the task. Also, simulators and interactive study aids are viewed positively by students and teachers.

3 IMPLEMENTING WatchSim

To reiterate, WatchSim is an interactive watch repair simulator that was designed to be run on a non-Pro Apple iPad with a standard-resolution screen. This simulator has two intended purposes:

- To teach the end-user basic watch anatomy, including parts' names and their intended purpose inside a timepiece
- To teach the end-user the standard configuration of a watch and allow him or her to see how each part fits together

Secondary benefits include helping the user organize parts in a workspace and helping the user become familiar with a particular watch configuration to improve repair time.

3.1 Development choices

WatchSim was created in Apple's Xcode IDE using the company's proprietary Swift programming language and its associated 2D graphics framework SpriteKit. Although I was new to Swift, SpriteKit, and iOS development in general, these were chosen as the language and graphics framework for their ease of use, purported easiness to pick up, and to make best use of Apple's distribution channels.

3.2 Device choices

While smartphones are more common than tablets, the number of parts required to be displayed on the screen at one time and their respective sizes make them an unsuitable choice. Once the tablet format was chosen, the iPad was the natural first choice as it has a large 9.7" screen size and has kept the same screen dimensions across all of its standard size models. Additionally, iPads are the most ubiquitous tablet in the world with Apple raking in almost 27% of the market share in tablet sales in 2018, nearly 10% higher than their closest competitor (Liu, 2019). Finally, developing for iPad comes with Apple's development resources like Swift, SpriteKit, and the AppStore.

WatchSim was optimized for the 6th Generation iPad, but will run adequately on any of the 9.7 inch iPad models, including the following:

- iPad 2, 3, and 4
- iPad 5th Generation
- iPad Air, iPad Air 2
- iPad Pro (9.7 in only)

The app may appear, but not be scaled appropriately or run well (if at all) on other Apple devices including iPhones, the iPad mini, and the larger iPad Pro models.

3.3 Using WatchSim

When first opening the app, the user lands at a plain and simplistic interface (Figure 1. below) where they can begin to disassemble the watch. To enforce

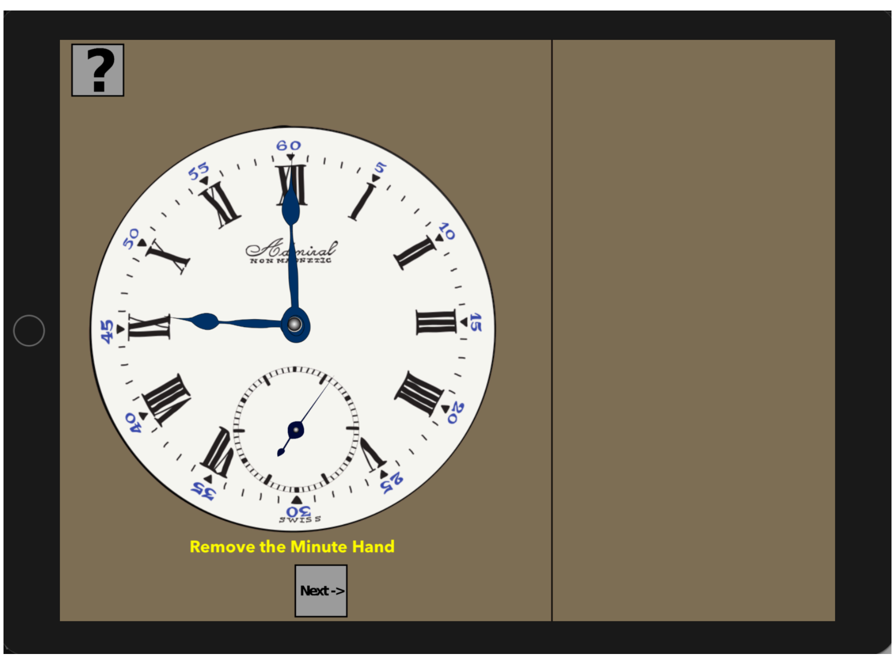

Figure 1. Landing page of WatchSim

consistency, parts can only be removed in a specific order and one at a tie. Disassembly instructions are provided and as the user goes through the simulation they are given educational snippets about each watch part.

To learn more about a part or find out which part is which, the user can tap on each visible, top layer part to learn its name and function. When the user finds the correct part, as indicated by the instructions for removal, they can simply tap and drag the part off of the watch to the workbench area (explained in the next section). When the correct part is moved off the watch, the next instruction is triggered.

Once the user has disassembled the watch a congratulatory message is displayed and they are prompted to reassemble. Reassembly follows the same steps as disassembly, though in reverse. When a part is dragged back to the watch, the part dragged to the watch in the prior step “snaps” into its correct position and is no longer be movable. This corrects for user error in part positioning.

At any time if the user wants or need assistance finding the correct part they can tap the hint button and the correct part will be highlighted in yellow. Additionally, activating the hint button during reassembly will prompt the user with yellow markers on which to place the parts (Figure 2. below).

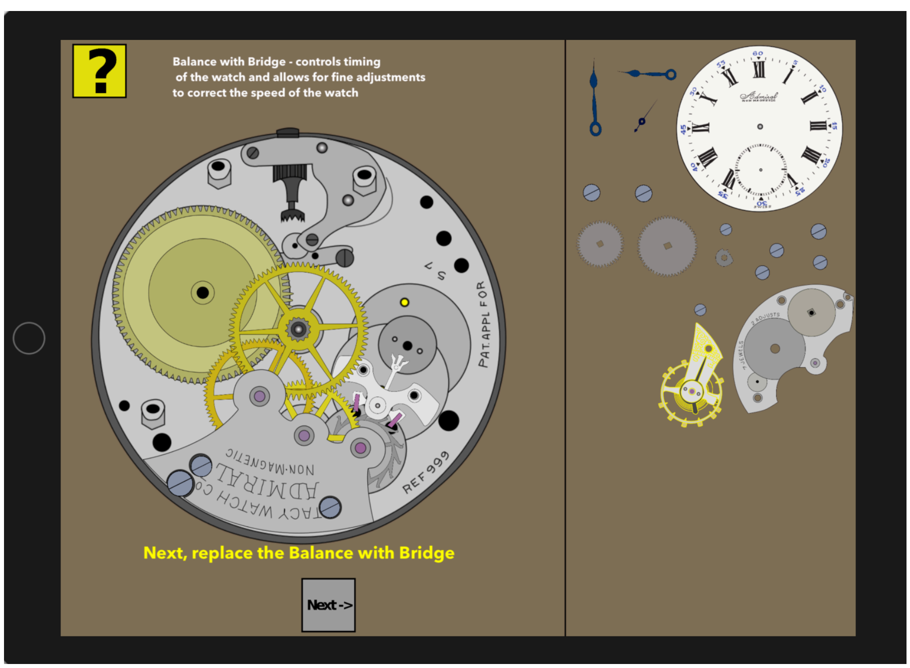

Figure 2. Hint button activated during reassembly

3.4 WatchSim user interface

In this application, every bit of the screen is usable for organization and parts storage, but there are six main components of the user interface that have significant intent. See Figure 3 below for reference.

- **A** - The body of the watch. This is where all parts are removed from and where they are replaced to.
- **B** - This label is where the part's identifier and description appear after a part is touched.
- **C** - The yellow text area by C is where the current instruction is displayed.
- **D** - The "Next ->" button only serves to dismiss the congratulatory messages at the midway point and end of the simulation.
- **E** - The area to the right of the black line is the recommended workspace area. For best results, keep all removed parts to the right side of the line.
- **F** - The hint button can be toggled on and off. When on, relevant parts and locations are highlighted to make the simulator easier.

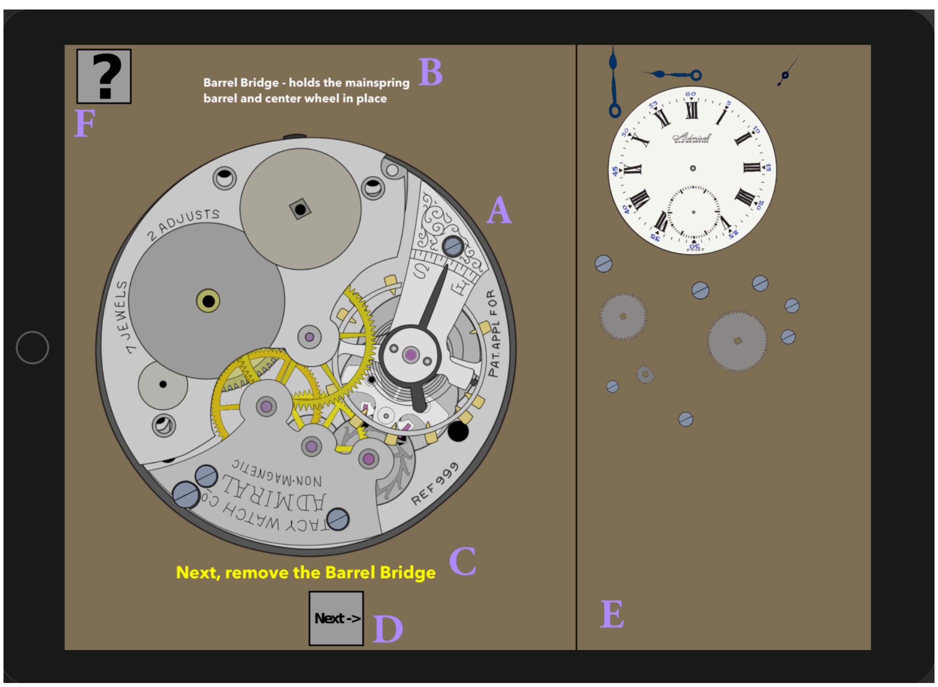

Figure 3. UI components

Parts were allowed to be placed anywhere to preserve the natural freedom a watchmaker has to organize his or her parts and tools how they prefer. Thus, the black separator line is just a recommended barrier to incentivize the user to attempt to organize the parts in a way that they all fit in a more compact space.

4 LIMITATIONS

4.1 Real world training limitations

WatchSim has limitations as an educational tool in the watch repair field. The first and most significant is that digital learning media can *never* provide the sort of manual dexterity practice or "muscle memory" that sitting down and manipulating tiny parts with tweezers can. Similarly, there is only so much a simulation can do for an individual's long term education. A user cannot sense the depth of the parts on a 2D screen, nor can they *feel* whether a part is in the right place. Furthermore, some watch movements are infinitely more complex with dozens more parts, which would not be possible to simulate in this app with the current setup.

4.2 Class scope limitations

If this course were twice as long there are several more features that would have been nice to integrate to create a more lifelike watch servicing experience, which would more even more educational. For instance, I had initially proposed to implement a tools feature with a magnifying glass and screwdriver tool with which the user could zoom in on parts and remove screws, respectively. Due to time constraints, these tools features were replaced with more user-friendly dragging and dropping of screws and auto-scaling parts.

Similarly, a few of the watch parts were not rendered individually (a contingency accounted for in the proposal) and were instead rendered as one part in the simulator. One of these parts is the "Balance with Bridge" that actually represents several components that would be beneficial for the user to see in the long run.

Finally, another valuable feature would be the ability for the user to oil the watch components. Appropriate oiling is one of the most important parts of watch servicing and this simulator medium would be an ideal way to learn and memorize oiling techniques.

5 CONCLUSIONS

The watch repair field has seen a steady decline in watchmakers over the years as older watchmakers are failing to recruit and maintain a younger generation of tradespeople. A major factor contributing to the shortage is archaic educational practices, including a near absence of educational technology. The current state of watchmaker education does not allow for teaching basic concepts quickly, efficiently, or at scale.

I have proposed and constructed WatchSim, a watch repair simulator that allows the user to familiarize him or herself with standard watch anatomy, including part names, purposes, and how the parts fit together in the watch. The finished product is user-friendly with a generally intuitive interface, and has all of the intended core functionality needed to allow the user to develop a basic understanding of watches and what makes them work.

6 FUTURE WORK

An individual looking to expand on WatchSim and its functionalities has a lot of room to help the application grow. Currently with the foundations in place a developer could easily replace the simple pocket watch the simulator is simulating with a high-end Swiss automatic watch like a Rolex or Omega. All the developer needs is a stack of well-rendered images and a set of instructions.

Further expansion could be done by implementing the features in section 4.2 - the tools and oiling functionalities. Also, in an effort to make WatchSim more useful practice for more seasoned repairmen and women, several watches could be loaded into the application with assorted issues. The task would be to fix all of the issues (broken teeth on gears, bent gears, etc) and then clean and oil the watch, providing a more realistic customer scenario.

7 REFERENCES

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