It's Dance O'clock: Design, Development, and Testing of a Motion-Deactivated Alarm Clock

Andrew Li
Oberlin College
Oberlin, Ohio
ali@oberlin.edu

Shana Li
Oberlin College
Oberlin, Ohio
sli2@oberlin.edu

ABSTRACT

College students are perennially exhausted, and getting out of bed is often a painful ordeal involving several sound-based alarms that are frequently snoozed or slept through. To alleviate the struggles faced by students in waking up in the morning, we introduce Dance O'clock, a motion-deactivated alarm clock program that utilizes the motion-capture capabilities of the Microsoft Kinect. Throughout our work, we designed, developed, tested, and evaluated the capabilities of Dance O'clock, which include the abilities to record a physical movement routine using the Kinect camera, set an alarm with a series of user-customized parameters, and deactivate the alarm by performing the previously recorded movements. In this paper, we describe and discuss the underpinnings of our work in the following areas: an initial nine-question survey involving 26 participants to gauge the market audience's interest towards our initial premise, formulation of Dance O'clock's design to accommodate the received feedback, and final user testing and survey to evaluate the feasibility and effectiveness of our application.

KEYWORDS

Kinect, alarm clock, movement recognition, dance, WPF application, C#, think-aloud testing

1 INTRODUCTION

For the contemporary college student, waking up early in the morning has become substantially difficult due to an increasing academic workload, extracurricular and social commitments, and biological changes in the body that consistently delay sleep onset [3]. Despite the challenges that students face in maintaining early-rise habits, universities continuously schedule early morning classes to maximize space utilization, which often results in incomplete attendance and poor academic achievement by students [4]. Hence, finding an effective way for college students to wake up timely and motivating a healthy lifestyle has become an imperative goal for our research.

The initial motivation for Dance O'clock arose from our personal experiences - we have both regularly encountered difficulty waking up in the morning for classes, often snoozing the alarms on our phone too many times, and eventually turning them off. We hypothesized that numerous other college students like us have had similar experiences, and would be interested in a solution that wakes them up effectively with more just sound, and that takes more than the easy press of a button to turn off. After confirming our hypothesis through a preliminary survey of members of our target audience, we developed Dance O'clock.

Dance O'clock is a motion-deactivated alarm clock in the form of a Windows application, which has a simple, easy-to-use interface that allows users to customize their alarms, and full integration of the Microsoft Kinect motion sensor for recording and validating user movement. The application was created in Visual Studio and written in C#, and the Kinect functionalities were integrated using the Microsoft Kinect SDK. Users are able to record a movement routine to perform when they wake up, save it, select it when creating an alarm, and attempt to match the movement given visual guidance when the alarm goes off to deactivate it. Users are also able to customize a series of parameters associated with the recording and execution of movements, including the length of their recording, the tolerance for matching movements, and the number of times their routine must be repeated for the alarm to turn off.

The purpose of Dance O'clock is to physically engage users in the morning via movement recognition, thereby invigorating them in the process, and ultimately motivating an active, healthy, and positive lifestyle. In a study published in "Movement, Health & Exercise", elementary school students who participated in physical education classes before class attained increased test scores, rated themselves more confident in their abilities, and showed significantly higher activity throughout the day [7]. Through Dance O'clock, we aim to replicate these effects on college students, and through comprehensive user testing, we confirmed the application's ability to more successfully invigorate users mentally and physically than traditional sound-based alarms.

The development of Dance O'clock also involved fundamental elements of participatory design: as college students, we personally experience severe problems when waking up in the morning, and often miss early classes and meetings as a result. Therefore, designing an application that would help us maintain a healthy lifestyle, a consistent sleeping schedule, and motivation to stay active throughout the day was very important. We also intermittently asked for feedback from target audience members who later became usability testers, and continued to apply relevant changes to Dance O'clock's interface throughout the development process.

This paper makes several key contributions: first, we introduce Dance O'clock, a novel solution to the common problems experienced by college students while waking up; second, we present the results of two phases of user surveys: a preliminary survey for target audience members, and a survey for users who underwent usability testing; third, we provide detailed discussion evaluating the success and implications of our solution, and propose topics for future work.

2 PREVIOUS WORK

Previous work has been done in the field of developing creative, non-sound-based alarms for those who do not find traditional alarms effective. For example, Island Dogs creates an alarm clock that deactivates after the user successfully points a laser at the center of a target [2], and Sofie Collin and Gustav Lanberg designed an alarm clock in the form of a floor mat that would turn off after the user steps on it [1]. However, after thoroughly researching the market and the applications of motion sensors, an alarm clock involving matching movements through a Kinect sensor has not yet been done to our knowledge. Therefore, we aimed to continue the trend of developing unconventional alarm clocks, emphasizing the aspect of physical movement and customization.

Movement matching has been a cornerstone of the Microsoft Kinect's capabilities since its introduction as an input device to the Xbox 360. Figure 1 shows a notable application of the Kinect to the game "Just Dance", where users dance to popular songs and try to execute pre-programmed choreography as cartoon characters with diagrams to guide them. Although Microsoft has discontinued support for the Kinect, the Kinect SDK is still widely available for download and user app development. Software Engineer Vangos Pterneas, for example, has used the Kinect SDK avidly to develop Windows applications involving body tracking. The coding tutorials posted on his blog were of great help to our understanding of the Kinect's body detection mechanics [8].

Figure 1: A screenshot of the Just Dance game, where players replicate pre-programmed choreography as cartoon characters and follow an instructive action diagram on the bottom right [6].

3 PRELIMINARY SURVEY & RESULTS

In order to guide the design and development of Dance O'clock, we approached 26 students from Oberlin College with an initial nine-question survey to gauge their sentiment towards our project's premise. The survey introduced the goals and theoretical functionalities of Dance O'clock and subsequently gathered responses from the participants regarding their morning behavior (if they considered themselves a "morning person", whether they struggled to get up in the morning, how many alarms they set for every morning), and their opinions on Dance O'clock's functionality (whether they would consider using Dance O'clock regularly, if they preferred their own music and movements, and features they wanted to include).

Results and Analysis

Figures 2-4 show the results of three survey questions that were of great influence to our design, as they addressed various components of functionality that we had not previously considered. While a substantial portion of participants responded that they only set one alarm for every morning, the majority reported that they set multiple alarms, with outliers setting as many as ten alarms. While we were initially more focused on the development of matching user input to the preset dance moves, we realized that it was important to have a user interface that supported setting multiple alarms, which we did not originally consider.

We also discovered that while the majority of users believed that their current method of waking up was sufficient, the overwhelming majority struggled to get up in the morning and around half slept through alarms or frequently hit snooze. We believed that this statistic bolstered our hypothesis that a more effective alarm clock would alleviate the aforementioned symptoms. Responses to this question also led to the implementation of a maximum number of snoozes

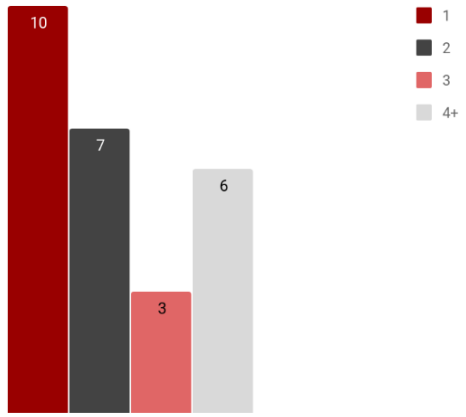

Figure 2: Responses to "Number of Alarms Set Per Night": Mean: 2.808, Median: 2, Mode: 1, σ: 2.370

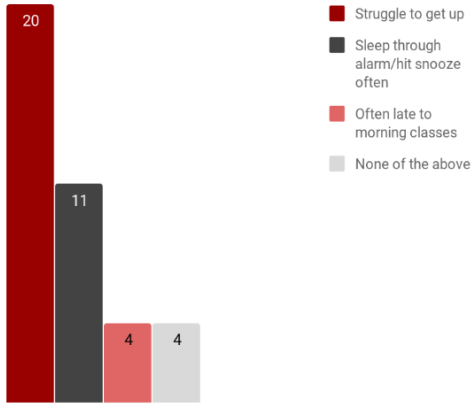

Figure 3: Responses to "Problems with Waking"

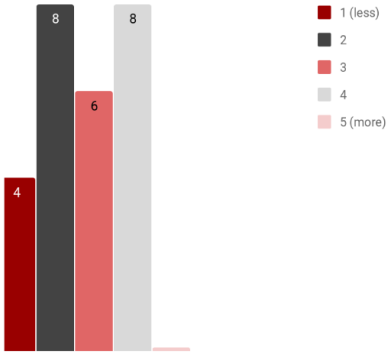

Figure 4: Responses to "Likeliness of Using Dance O'clock" Mean: 2.692, Median: 3, Mode: 2,4, σ: 1.066

available to prevent sleeping through and snoozing too frequently, which were very common problems among those surveyed.

Overall, we received lukewarm sentiments from users with regards to whether or not they would consider using Dance O'clock regularly. Most participants thought that it was "too much work" to perform strenuous physical activity so early in the morning, with one memorable response detailing that Dance O'clock was "a terrifying idea", while only three participants would only consider using the application in dire situations. Most participants' greatest worry was that they would fail to match movements well enough to turn off the alarm. From this result, we decided to design our application around more stretching-based exercises that were slower and less physically demanding than intensive dance movements, and consider adding more possibilities for user customization, such as a timeout function that would skip frames if users continuously fail to match movements.

4 APPLICATION

The foundation of our design goals was derived from user responses in our preliminary survey. Our goals are categorized as 'Must Have', 'Should Have', and 'Would Be Nice' in order to indicate the degree of importance each goal had in our final design. We were able to complete most of our design goals, and left only three of our "Would Be Nice" goals unattained: the ability for alarms to wake up a sleeping computer, Spotify playlist integration, and detecting freestyle movements in real-time.

Must Have

The "Must Have" category of our design goals consists of features that are essential to the functioning of Dance O'clock, and would address basic user desires. Full Kinect integration and an intuitive user interface were trivially included as the two features were the basis for this study. We also included goals for 3 preset alarm sounds, 5 preset movements, and an ability to add custom sounds and music after participants of the initial survey were essentially split into thirds on whether they wanted present options, custom options, or both; we logically chose to have options for everyone. We also decided to create a failsafe system to turn off the alarm in the event that the alarm would fail to turn off due to many concerns raised by initial survey participants. While we acknowledged that including such functionality could defeat the purpose of Dance O'clock, a failsafe is much like closing the alarm app on your phone or deactivating a physical alarm clock and is essential in the event that the alarm cannot be deactivated as intended in order to prevent further inconvenience.

Should Have

The "Should Have" category of our design goals includes features that we did not deem as basic components of Dance

O'clock, but rather those that should be implemented nonetheless in order to maintain ease of use. We felt that the snooze function requested by users was important to implement, albeit with a limit to number of times it could be used, and a static illustration of the movements on screen to guide the users in deactivating an alarm.

Would Be Nice

The "Would Be Nice" category of our design goals contains design goals that would add to the usability to Dance O'clock, but would not limit its functionality if not completed. Of the goals that we met, the one of utmost importance was displaying real-time illustrations of a user's movement against the action they are trying to match. Moreover, we also added the ability to record custom movements and specify the number of times to loop routine before the alarm was deactivated. We were unfortunately unable to meet our goals for waking the computer when an alarm activated due to BIOS issues and did not implement Spotify integration and detecting freestyle movements due to time constraints.

Design

The main user interface window consists of a list box element containing all alarms and six buttons in the sequence we anticipated that they would be pressed: *Record Action*, *New Alarm*, *Delete Alarm*, *Modify Alarm*, *Toggle Alarm*, and *Help*.

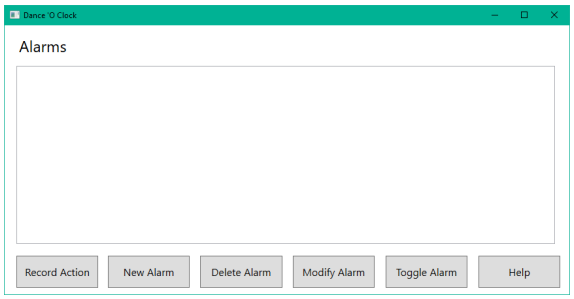

Figure 5: Main User Interface Window

The user begins by recording a movement routine that they will be required to perform to deactivate an alarm. The *Record Action* button launches a "New Action" pop-up window that allows users to specify the duration of the dance and how frequently to sample key frames, which are the frames that will eventually need to be matched by the user's body upon deactivation. Frame matching is accomplished by comparing the angles of the users' joints to the angles recorded in the key frames and verifying all angles lie within a user-designated margin of error.

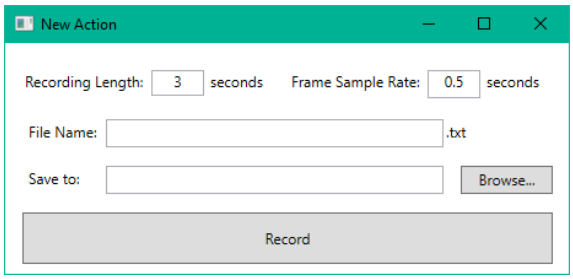

Figure 6: New Action Pop-up Window

The *Record* button in the "New Action" pop-up window opens a full-screen "Kinect" window that displays a video feed from the Kinect device with a blue stick-figure skeleton dynamically overlaid on top of the user, to visually indicate the beginning of the recording and inform the user of what the Kinect is recording in real-time.

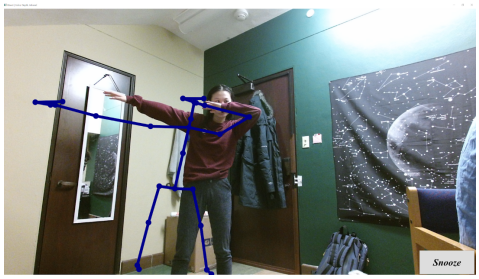

Figure 7: Record Action Pop-up Window

After the designated record time, the "Kinect" window closes and the user is presented with the main user interface window again. The user can then opt to create new alarms through the *New Alarm* button, which launches a "New Alarm" pop-up window. The user sets the music, action required to deactivate the alarm, the time and date for the alarm to activate, the number of times that the action must be completed in order to deactivate the alarm, the tolerated angle error for matching frames, and the maximum amount of time spent on a key frame before Dance O'clock skips it, as long as the user is constantly in the Kinect's field of view. The *Modify* button opens the same pop-up window as the "New Alarm" window but with all the fields filled in, and the user is able to make changes to the alarm's settings.

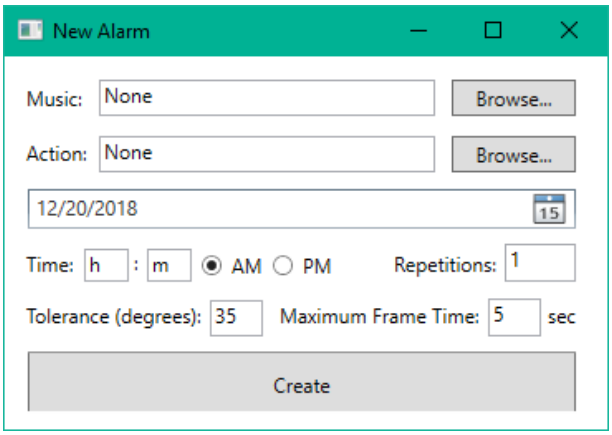

Figure 8: New Alarm Pop-up Window

After the "Create" button is pressed in the "New Alarm" window, a new alarm entry is created in the main user interface window containing a tag indicating whether the alarm is active, the music that will be played, and when the alarm will go off. Alarms are dynamically grouped by whether they are inactive or active, and sorted in chronological order by activation time in order for users to easily access alarms.

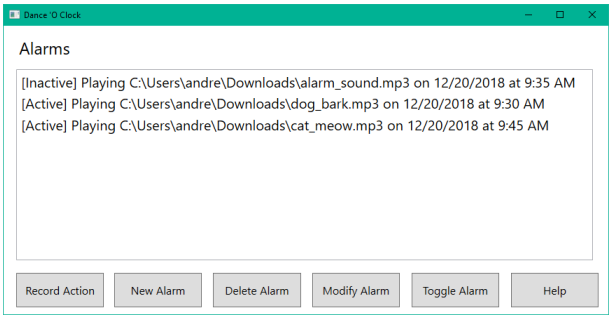

Figure 9: Populated Main User Interface Window

At the designated time, the alarm activates by playing the music file bound to it and opens a a full-screen "Kinect" window. Like the window that opens when recording an action, the window consists of a video feed from the Kinect device with a blue stick-figure skeleton dynamically overlaid on top of the user, but also with a maroon skeleton illustrating what the key frame that should be performed by the user looks like, in order to visually convey to the user how to deactivate the alarm. Each time the user matches the joint angles in the key frame, the next key frame is rendered. When there are no more key frames left, the alarm music stops, the "Kinect" window closes, and the aforementioned alarm is listed as deactivated in the main user interface window. The red dots on the blue skeleton indicate an incorrect joint angle that must be corrected in order to match the key frame.

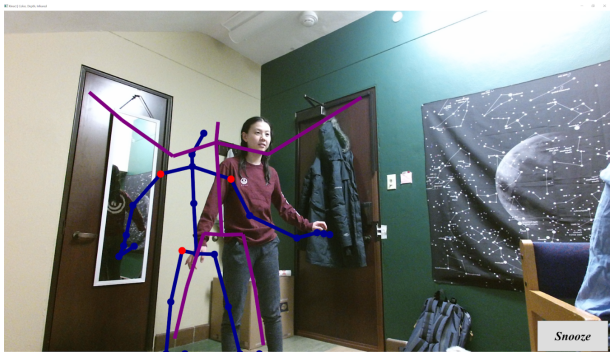

Figure 10: User Deactivating Alarm

The *Delete* button deletes an alarm entirely and removes it from the main user interface's list box element, the *Toggle* button sets an alarm to either "active" or "inactive" and sorts the list box accordingly, and the *Help* button launches a pop-up window containing a short list of instructions on how to use Dance O'clock, which we believed beneficial given the novelty of the scope of our project.

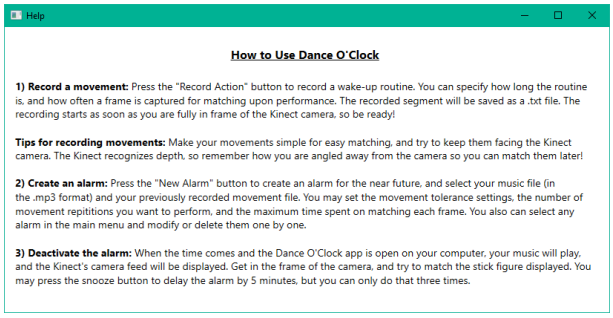

Figure 11: Help Window

5 USER TESTING

Our final user testing phase applied the "concurrent think-aloud testing" method iterated in [5] to 12 participants. All testers were Oberlin College students aged from 18-23, with 10 of the participants testing the application during the day and two testing it overnight, practically using it as their alarm clock to wake them up in the morning. After signing an electronic consent form, the testers were asked to perform the following tasks:

(1) Open and read the help menu.
(2) Record an action.
(3) Create and set up a new alarm for the coming few minutes, or in the case of overnight testers, for the next morning.

(4) Modify one of the alarm's attributes.
(5) Wait for the alarm to go off, and then perform actions to deactivate the alarm.

For every step, the participants were asked to iterate their goal, the steps that they took to achieve it, and any comments they had on any aspect of the application. After completing the tasks, the testers were asked to complete a 20-question survey, which asked them to rank and comment on the ease of use for each key function (recording an alarm, creating and setting an alarm, and deactivating an alarm) and the application in general, what they liked and disliked about the application, whether or not they would use it regularly, and how it compared to their usual alarm system.

Results

All users successfully figured out how to create an alarm, set it up, and deactivate it. However, a problem that most users experienced was figuring out how to modify the alarm - many clicked the modify button without selecting the alarm in the list, but after either mousing over the window or consulting the help menu, they eventually figured it out. This is a problem that would specifically occur with only one alarm in the list, since users would intuitively select an alarm to modify if there were multiple. However, this observation along with user feedback suggests that the modify function should be clarified.

Unfortunately, no participants were able to locate the preset movements and music files. This can be attributed to the users' unfamiliarity with the Windows file navigation interface, as well as the lack of clarity of the existing file management system. The default path was set to the Desktop, which was the most commonly used directory since users were asked to save their files there. Combined with many comments that the files were difficult to navigate, this problem elucidates that the existence of preset files should be indicated more clearly in the application, and that their locations should be loaded in the interface by default.

Figures 12-14 display the participants' rankings of each application functionality's ease of use. Participants consistently rated the usability creating and setting of the alarm higher than the ease of deactivating an alarm, affecting the score for Dance O'clock's overall ease of use. This result speaks well about the usability of our interface, but indicates that there are improvements to be made to our mvoement matching algorithm as well. A common problem that users faced was the difficulty in correctly matching all of the angles when deactivating the alarm. Because the Kinect sensor is very sensitive to depth and users usually do not remember how exactly they were oriented with respect to the sensor upon

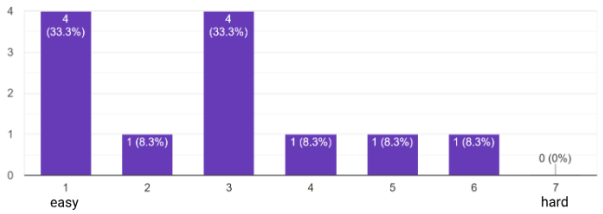

Figure 12: Rate Ease of Creating & Setting Alarm
Mean: 2.75, Median: 3, Mode: 1,3, σ: 1.658

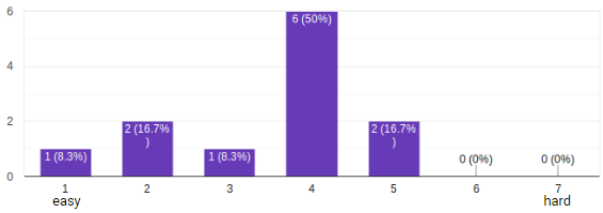

Figure 13: Rate Ease of Deactivating Alarm
Mean: 3.5, Median: 4, Mode: 4, σ: 1.243

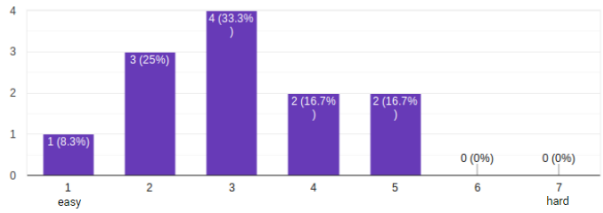

Figure 14: Rate Overall Ease of Use
Mean: 3.083, Median: 3, Mode: 3, σ: 1.24

recording, some angles would not match even if the user's blue stick figure aligned with the purple guide. The timeout function then proved useful for users who were stuck on certain frames. However, it is worth considering that Dance O'clock is meant to be more difficult to deactivate than a regular alarm, and to a certain extent, the effort put into matching a difficult movement is reflected in the amount to which the user becomes awake and energized.

All users indicated confusion in understanding the wide array of settings that could be changed. Because we aimed for a simple and easy-to-use interface, the settings were abbreviated with terms that generally describe their purpose, such as "sample rate" for the time elapsed during a recording until a new frame is captured, and "maximum frame time" for the time spent on matching a frame until it is automatically skipped. Although there existed informative tool tip text that would appear after hovering the mouse over every element, it was missed by the majority of users. By allowing for as much

customization as possible, users were more prone to become overwhelmed with unfamiliar information. This presents the possibility for changes to the wording of the options, new ways to display information about them, or adding a separate "advanced" settings tab that would eliminate clutter in the main windows.

The most common improvement recommended by the users was including a countdown when recording an action as the moment the user entered the field of view of the Kinect after hitting the "Record" button, the program would begin to record, often confusing users and creating unwanted frames at the beginning of a dance. Moreover, multiple users requested sliders and drop down menus, similar to a mobile app on a phone, rather manually inputting alarm and action parameters because creating multiple alarms became laborious.

Overall, the feedback given via think-aloud testing was warmer than we initially expected, compared to the neutral tone of the feedback given in our initial survey. All participants agreed that the alarm served its purpose to wake users up more effectively than a traditional alarm, regardless of whether or not the movements were successfully matched. However, there is a consensus that Dance O'clock is not something that should be regularly used, although about half of the testers mentioned that it could help greatly in dire situations and for people who are completely desensitized to traditional alarms.

6 DISCUSSION

Implications

The results of the preliminary survey indicate that the vast majority of users face problems while waking up in the morning, while the feedback given in our comprehensive user testing survey demonstrates that users believed that Dance O'clock is a robust option for waking up in high-pressure situations. These two factors indicate that there is sufficient opportunity for further work in sleep habits and wellness in Human-computer Interaction research. While Dance O'clock cannot act as an everyday solution to maintaining punctuality in the morning, our studies indicate that it acts as an effective emergency alternative. This investigation has opened up further avenues for exploring Human-computer Interaction's role in managing sleep hygiene and patterns by demonstrating the effectiveness and positive reception for a niche solution to a large problem.

Learning from the User

Users occasionally surprised us by interacting with Dance O'clock in ways we did not anticipate. For example, there was a testing approach that we did not expect - the user was committed to staying in "bed" for longer, so they turned the Kinect towards the table, and recorded movements while sitting up on it. The movement recorded successfully, but had some initial trouble detecting the user in the frame. Upon deactivation, the movements would not capture properly because the user was not in standing position, but the timeout function was exploited so that the alarm turned off eventually without the user doing anything. While "cheating" the alarm system is certainly possible and we recommend against doing so, any method of waking up can be cheated if the user willingly chooses to do so, thus we did not find this to be any worse than turning off an alarm on your phone.

Another instance when user behavior surprised us was when a user decided to jump during a dance, an action we had not anticipated, which led to awkward key frames captured during the jump and leaving the user unable to replicate the joint angles of each frame in the jump. We also observed many users struggling to create alarms during the testing phase as they kept leaving the action file and music file paths, which are listed at the beginning the "New Alarm" window user interface, blank. We soon realized that users were most concerned with setting the time that the alarm would activate, leading to them often skipping setting music and an action and subsequently forgetting to do so after setting a time.

While designing and developing a technical solution to a real-world problem, it is impossible to fully anticipate all possible user behavior and make adjustments for all users' reactions. As developers, we can only aim to create a solution that satisfies as many users as possible, and an incredibly valuable tool to help us do so is participatory design, where we constantly gauge user feedback and adjust our application to fit as many user desires as possible. Ultimately, the design and functionality of an application can always be improved, and we aim to continue this process with further development of Dance O'clock.

Limitations

In terms of our methodology, the think-aloud testing strategy, coupled with the lengthy survey that participants were asked to complete, were very effective in gathering a large amount of user feedback. However, the sample size was limited to a small population of 12 participants, with only two who tested overnight. Furthermore, most testers did not experience significant problems with their regular alarms, which

limited their valuation of Dance O'clock. To gather a more accurate rating of the application's effectiveness, the overnight testing group should be expanded, and the population for whom regular alarms are particularly ineffective should be targeted.

7 FUTURE WORK

For our future work, we plan on completing our "Would Be Nice" items, including integrating the ability to wake up the computer when an alarm goes off, allowing users to add music from Spotify using the Spotify API in C#, and recognizing high-velocity freestyle movements. The next step in improving Dance O'clock would be detecting faster movements in general and being able to replicate smooth actions, as we are currently limited to frame-by-frame matching of slow, well-defined movements. Although we are limited to the capabilities of the Kinect hardware, code optimization could be applied to alleviate latency and improve speeds.

From the suggestions given during user testing, we would like to implement better file management and navigation, in particular displaying the file paths to the preset movements and music files by default, since none of the testers could find them. Moreover, we would like to reorient parts of our user interface to be more intuitive, such as having the user set the music and action path last rather than first when setting a new alarm. We would also like to add OS X and Linux compatibility, as it was obvious from testing that most users are more familiar with other operating systems. Finally, the ability to save and load alarm information upon closing and re-opening the application is vital for long-term use.

Our user testing phase involved a small number of 12 participants, with only two who tested the alarm overnight. In the future, we plan to expand testing beyond the college student population, especially for the overnight arrangement, and actively seek out users for whom regular alarms are extremely ineffective.

8 CONCLUSION

This paper describes the motivation, development process, and user testing results of Dance O'clock, a motion-deactivated alarm system. As college students struggling to wake up from sound-based alarms on our phones, we embarked on the mission to develop a novel alarm system that would effectively energize us and motivate us to maintain healthy sleepy hygiene practices. Based on a preliminary survey of college students like us, we came to understand the extent to which the student body is plagued by problems with waking up in the morning, and designed Dance O'clock as a Windows application able to record movements, set alarms, and deactivate alarms via movement recognition through the Kinect. After our final think-aloud testing phase, we determined that while there are improvements to be made to Dance O'clock's functionality and interface, the application delivered on its promise, and was greatly more effective than sound-based alarms in invigorating users in the morning and promoting activity.

ACKNOWLEDGMENTS

We would like to thank professor Cynthia Taylor for her unwavering support and guidance throughout our project, and for organizing an enjoyable, informative, and overall incredible class for us this semester. Our knowledge of Human-computer Interaction blossomed under her tutelage and we both hope to enroll in more classes with her in the future.

REFERENCES

[1] Inc. Amazon.com. 2007. STAND UP TO WAKE UP, SIMPLE AS THAT. (2007). Retrieved December 20, 2018 from http://www.yankodesign.com/2007/06/19/carpet-alarm-clock/

[2] Inc. Amazon.com. 2018. Laser Target Alarm Clock. (2018). Retrieved December 20, 2018 from https://www.amazon.com/gp/product/B001AZMGK6?ie=UTF8&tag=bplin-20&linkCode=as2&camp=1789&creative=390957&creativeASIN=B001AZMGK6

[3] MD Brandon Peters. 2016. How Delayed Sleep Phase Syndrome Affects Teenagers. (2016). Retrieved December 20, 2018 from https://www.verywellhealth.com/delayed-sleep-phase-syndrome-in-teenagers-3014763

[4] Linda Carroll. 2016. 8 a.m. Class Fail: Sleepy College Students Flunking Out. (2016). Retrieved December 20, 2018 from https://www.nbcnews.com/feature/college-game-plan/8-m-class-fail-sleepy-college-students-flunking-out-n547216

[5] Duarte et al. 2018. Participatory Design and Participatory Research: An HCI Case Study with Young Forced Migrants. *ACM Transactions on Computer-Human Interaction* 25, 1 (September 2018), 1. DOI: http://dx.doi.org/10.1145/3145472

[6] Megan Farokhmanesh. 2013. Just Dance 2014 tracklist announced, includes Lady Gaga, Psy and more. (2013). Retrieved December 20, 2018 from https://www.polygon.com/2013/9/23/4763090/just-dance-2014-tracklist-announced-includes-lady-gaga-psy-and-more

[7] Tayler Greene. 2017. Study: Exercise Before School Benefits Students Throughout the Day. (2017). Retrieved December 20, 2018 from https://education.uncc.edu/study-exercise-school-benefits-students-throughout-day

[8] Vangos Pterneas. 2018. Mixed Reality + Motion Technology. (2018). Retrieved December 20, 2018 from https://pterneas.com/