ECO ECO: Changing Climate Related Behaviors For Cellphone-Based Videogames

Yan (Rock) Zou, Nahal Mustafa, Nahil A. Memon, and Mohamad Eid
Applied Interactive Multimedia (AIM) Laboratory
Division of Engineering, New York University Abu Dhabi, United Arab Emirates
{rock.zouyan, nahal.mustafa, nam432, mohamad.eid}@nyu.edu

ABSTRACT

Global climate change has become a major issue of today's human society. Since most of our human activity could potentially have big environmental impacts once accumulated, it is especially important that the public is educated with the environmental effects of their daily actions. This paper's main purpose is to propose a gamified system that leverages the high saturation of smartphones and the rising popularity of Internet of Things (IoT) to educate young children with environmental concepts as well as encouraging them to commit to real-life "green habits". An android mobile game Eco Eco was developed to demonstrate the concept and test the proposed system's effectiveness for young users. This Farmville-like game is played only by conducting real-life environmental activities like using a reusable water bottle, walking more steps instead of using cars, or reduce usage of household electricity. The game, developed with Unity3D utilizes the Google Fit API for step count, CloudSight API for image recognition and a connected smart device for monitoring energy usage. A preliminary user test was also conducted to improve the usability of the system as well as to test the effects of this system.

Keywords – Serious Games; smartphone; haptic communication system; technology for visually impaired.

I. INTRODUCTION

Global warming has now become one of the biggest issues of human civilization. The rising water level is destroying many species' habitats and many people's homes. At the current rising rate, the sea level will submerge the entire Maldives within 50 years. One of the biggest culprit for global climate change has been identified as the rising amount of carbon emission. Our daily actions play a significant part in the process of accumulating green-house gas in the atmosphere. To educate the public on developing green habits, historically, there have been numerous campaigns, publications, etc. Many new smart devices also factored in its environmental impacts by showing the user their carbon imprints. However, so far, most of the efforts have been about giving out information for the users/readers to make more informed decisions. That is to base the actual effect of those methods on the assumption that the users do have the strong incentives to follow through the environmental initiatives once they are told about them. It might be true for the adult population where they could understand the severity of the issue more clearly. However, young children are much less prone to be attracted by many of the abstract environmentalist notions like climate change and carbon emission. Therefore, only presenting them with information about the issue or telling them what to do or what not to do could be boring for them. There have been researches proving that gamification gives users bigger motivation in completing seemingly boring tasks [1]. There have been different attempts to introduce the concepts of gaming to this education process. For example, Eco Ego (Figure 1), a web-based flash game, tries to tell the young players the environmental effects of their daily actions by visually displaying the damages caused by the users' unenvironmental decisions [2]. Although more interesting than simply presenting the concepts with only text or still images, as far as the actual environmental effect goes, those games are informational at best.

Fig. 1: The interactive visuals make the environmental messages much easier to understand.

With the ever more powerful sensors on smartphones and tablets and the advent of smart appliances and IoT, developers now have access to users' everyday real-life data. This enabled the proposed gamified real-life-based feedback system possible. At the core of the proposed gamified system is a Farmville-like eco-system building game named Eco Eco, where the player's objective is to create a healthy and diverse eco-system by spending points and expanding land. Different from most other games, however, Eco Eco only rewards the player with points and opportunities to expand land when the player could complete real-life challenges like walking 5000

978-1-4673-9175-7/15/$31.00 ©2015 IEEE

steps in a day, using a reusable water bottle or reducing the electricity usage at home. With the built-in gyroscopes, accelerometers, and GPS sensors, the smart devices could sense the user's walking steps, distance and even transport data; with the camera and cloud-based image recognition service, developers could know about the elements within the environment the user lives in (like a water bottle, or a thermostat); with smart energy sensing devices, like smart plugs, it is also easy to start measuring the user's electricity consumption directly. To introduce interfaces beyond just a screen and device is to encourage the users of the system to actually commit to environmental actions in their real-life. Furthermore, the game Eco Eco itself is designed to be fun and even addictive (for a good cause). It is developed with Unity3D, one of the most popular and powerful 3D game engine, draws inspirations from many successful games popular among children, including Minecraft, a sandbox survival game, and Clash of Clans, a massive multiplayer online mobile game. Making the game interesting is the prerequisite for incentivizing the players to follow the instructions and complete challenges for resources. A complete game play also encourages the player to come back to the game and keep playing, which means the players will commit to the green habits for a longer period of time, since their only way to keep playing is to adopt green habits in real-life.

The remainder of this paper is organized as follows: section 2 gives a description of the Eco Eco game's premise, the gameplay and the reward and punishment systems; section 3 describes the software and hardware architecture to a prototype for the proposed system; section 4 is a brief summary of the findings and feedbacks from the usability test; section 5 summarizes the content of the paper and points to a few possible future directions for this system.

II. THE ECO ECO GAME

The game is built upon a scenario where the rising sea level is a visual representation of the environmental effects of our actions in real-life.

A. Background and objective

The game is set at a post-apocalypse era where the sea level has risen so high that only a small piece of land is still above water. The objective for the players is to lower the sea level so that there could be more land above water. At the same time, they should also use the coconuts (in-game currency) to create animals and plants to build a more diverse and robust eco-system (a snapshot is shown in Figure 2).

B. Real-life challenges offered by the game

In order to gain more coconuts and lower the sea level, the player can complete different types of challenges in real-life. Those challenges include walking 5000 steps and using a reusable water bottle. The sea level is constantly rising slowly, drowning every plant and animal it reaches. Therefore, the player has to keep completing the challenges to battle the rising sea level. There's another implicit challenge that is to keep the electricity consumption low because the rate at which the sea level rises is determined by the amount of electricity usage. The more you consume power, the faster the sea rises.

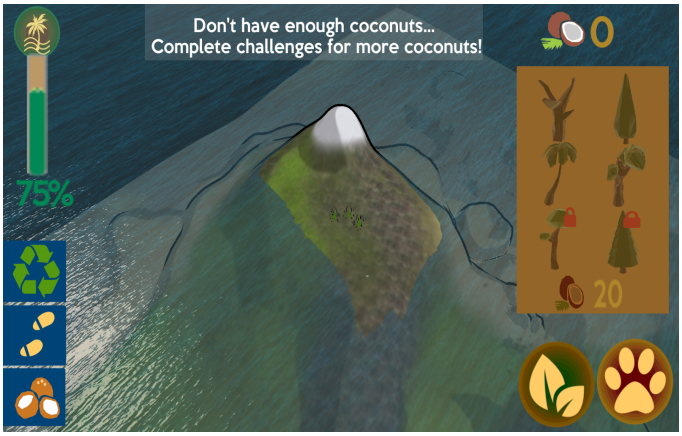

Fig. 2: Only a very small land is still above water.

C. The plants, the animals and the eco-system

As mentioned before, spending the in-game currency - coconuts, could create animals and plants (Figure 3). The game setting dictates that they are all land species. Therefore, when the rising sea level submerges them, they will drown (get destroyed). The players therefore has the incentive to keep the sea level lower to both gain more land and keep their creatures safe.

Fig. 3: Use the coconuts to create animals and plants.

III. SOFTWARE AND HARDWARE ARCHITECTURE

The system works by using the game Eco Eco to introduce the user to real-life challenges. Whether the user has completed the challenge is then verified by the data measured by the built-in sensors on the smartphone/tablet, and an Arduino-powered smart energy measuring unit. After being processed, the game could determine whether the user has indeed completed the challenge in real life and reward or punish the user in the game accordingly. The architecture for the energy saving challenge is shown in Figure 4.

Apparently, as for the walking challenge and reusable water bottle challenge, we could use just the built-in sensors on the smart phone.

A. The Game

The game is developed with Unity3D game engine. Many pre-made Unity Assets were used to create this game. Those assets include models of the characters, terrains and movements, as well as some important utilities. For example, the asset BestHTTP was used to enable simple-to-use HTTP calls to the image recognition service; the Uniduino asset was

used to enable the interaction between Arduino-powered electricity measuring devices and the unity game.

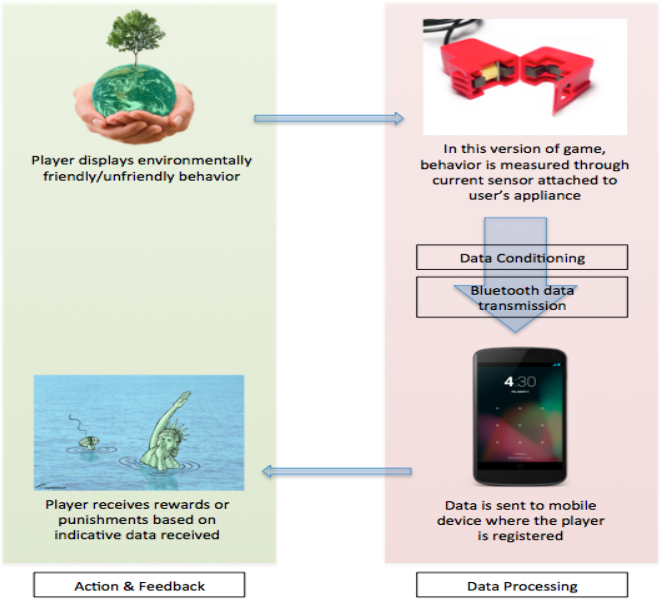

Fig. 4: The software architecture for the Eco Eco System.

The game introduces the player to the storyline with 3D visuals and sound, so that the player stays interested. The GUI and the on-boarding tutorial present the user the objectives -- lowering sea level and creating more species with more coconut. It uses text to introduce the player to the challenges that could help the player fulfill the objective. The visuals and the interactive elements of the game are essential in attracting young user's attention. At the same time, it is also the information outlet to direct the user's actions into real-life. Figures 5-6 show two examples of texts and visuals that are used to cue the user for what to do and why it is important.

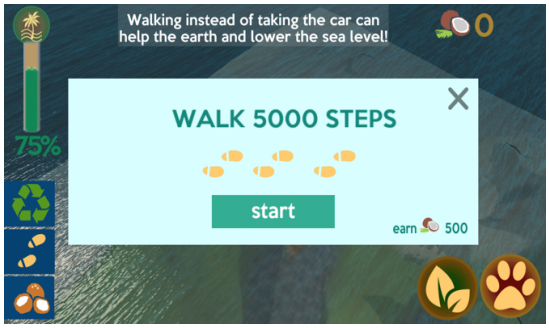

Fig. 5: Texts and some visuals are used to cue the user for what to do and why it is important.

Fig. 6: Texts and some visuals are used to cue the user for what to do and why it is important.

B. Verifying Challenges with Sensors

For three different types of challenges, different types of sensors are used, as described below:

Walking Challenges: First to be able to get the walking step data, the Google Fit API is used directly. This API is available through a java self-compiled .jar library. The API is called periodically to check on the progress. Whenever the current step count exceeds the target step count, the challenge is completed and the rewards are given.

Image Recognition Challenges: One of the most expandable features of this system is the cloud-based image recognition. For challenges that can be proven done with the visual presence of certain objects, the image recognition function can be used. For example, if a challenge is to use reusable water bottles instead of disposable water bottles, the user can complete it by taking a photo of a reusable water bottle once a day. This certainly is not bulletproof, since the user could always borrow a bottle and able to complete such challenges repetitively, the most convenient way is to actually carry a reusable water bottle around. The game first gives the user the prompt to take a picture of certain objects (Figure 7).

Fig. 7: Start the challenge by clicking on the intuitive camera button.

Once the user clicks the camera button, the built-in camera is activated and the user can take a picture of the required object – in this case, a usable water bottle (Figure 8). Once the picture is taken, the Unity3D asset BestHTTP is used to send the image taken by the user to the Cloud-based image recognition API CloudSight. This API takes any image and uses its neural network algorithms to determine what objects are present in the image and returns a string describing the object.

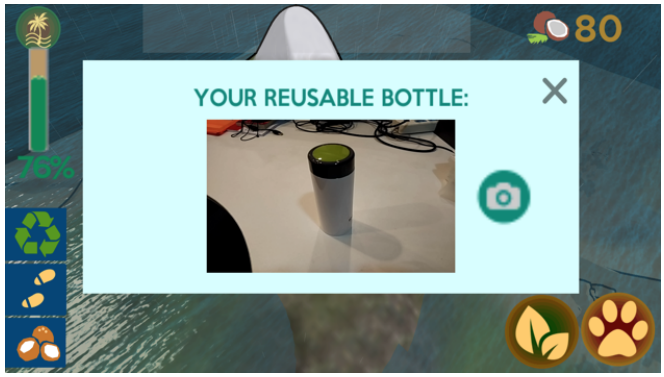

Fig. 8: Take a picture of the object and a string describing it will return.

An algorithm is run to cross check every word in the string against a dictionary of “waterBottleDisctionary” and “bottledWaterDictionary”. The dictionary “waterBottleDisctionary” stores string values such as “aluminum”, “glass”, “metal”, “proof”, “purple”, “reusable”, “steel”, “spill”, “silver”, “sports”, “thermos”, “tumbler”. The dictionary “bottledWaterDictionary” stores strings like “bottled”, “clear”, “drinking”, “arwa”, “evian”, “nestle”, ”putrified”, “volvic”, and ”voss”.

If among all the words in the returned description of the object, there’s no word from the bottledWaterDictionary and there’s at least one word from the “waterBottleDictionary”, the system dictates that the water bottle is reusable. Then the rewards will be given - the coconuts will be rewarded (Figure 9) and the sea level will be lowered (Figure 10). This would give the user more land and enable the user to create more creatures. This same mechanism could be used to distinguish reusable shopping bags from plastic bags.

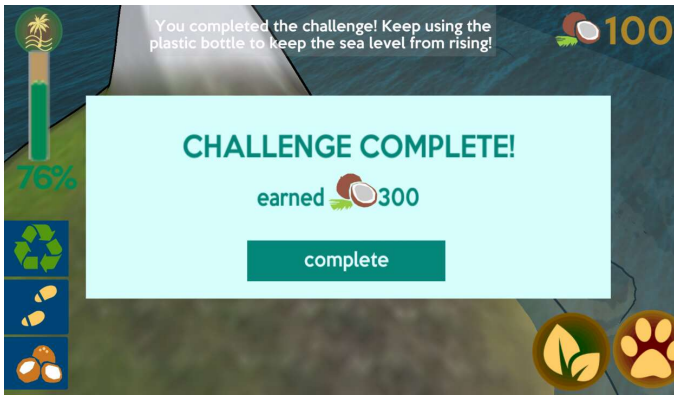

Fig: 9. When the verification is done, the in-game rewards will be given.

Fig. 10: The completion of the water bottle challenge lowers the sea level.

Electricity Saving Challenge: As mentioned before, there is an implicit challenge to keep the energy consumption at a low level. Although keeping all functions and sensors within the phone is a very convenient feature, the promises brought by the advent of IoT should also be leveraged in this gamified system. At the hopefully not-so-distant future, where smart appliances are common, it should be possible that the proposed system makes use of them.

To demonstrate the possibilities of using IoT with the proposed system, an Arduino-powered electricity-sensing device is built to measure the energy consumption rate (Figure 9). The device uses an Arduino Leonardo and the EmonTx open source energy monitoring hardware with EmonLib, an open source energy monitor library [5].

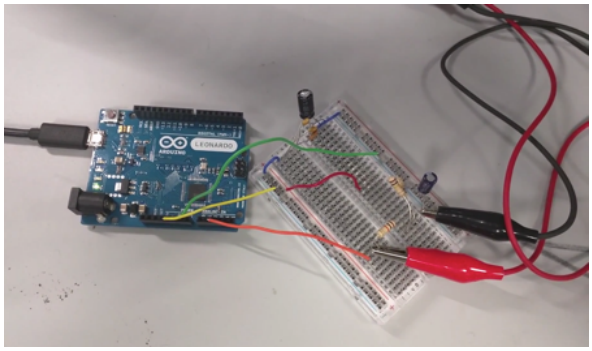

Fig. 9: Arduino Prototype for electricity monitors.

A CT Sensor, SCT-013-030 model made by Yhdc, is used in the current implementation to measure electric current flow. The CT sensor can measure a maximum current of 30A and can produce a 0-1V output. The nonlinearity is ± 1% and there is a 62Ω built in sampling resistance. The number of turns in the secondary wiring is 1800 and the device can work well between -25—70 degrees Celsius. A split core CT sensor was used with an opening size of 13 mm x 13 mm.

IV. User Test And Future Directions

To prove the effectiveness of the concept, one user test was conducted with the developed prototype among three girls from 8 to 10 years old (Figures 10-11). We found that this game had a positive effect in encouraging this small group of young students to make environmental and healthy decision.

Fig. 10: They were presented with the walking challenge.

A second usability test was conducted with 10 students of the similar age group (8-12). Among all the young players that the game was tested with, 9 had

changed their real-life actions because of the game and 8 played this game for more than once. This result effectively proves that such system does provide the young players with better motivation to follow through some real-life green habits.

Fig. 11: This girl asked everyone to walk the stairs instead of taking the elevator because stairs give more coconuts.

A third usability study was conducted for the GUI design of the game. Figure 12 shows a user performing the usability testing for the GUI design. Figure 13 shows the updates made, based on the usability testing, to include the information bar on top and more text feedback on users' actions.

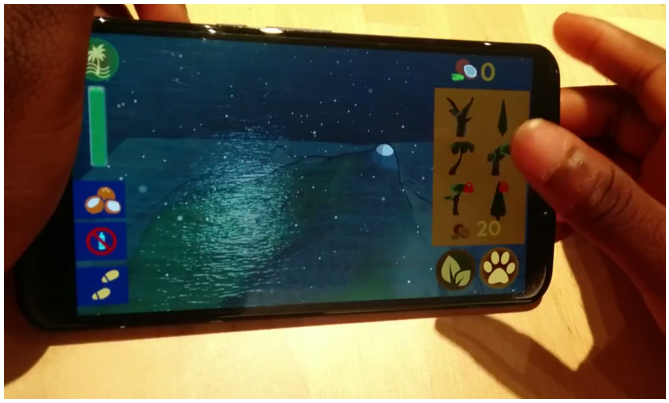

Fig. 12. A snapshot of the usability testing for the GUI design.

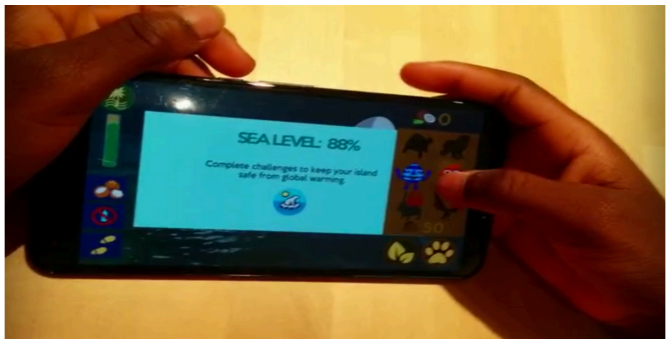

Fig. 13: The information bar on top and more text feedback on users' actions updates.

V. Conclusion & Future Work

We developed a serious creation type game in which the player is presented an island that has been almost fully submerged in water due to the negative effects of global warming and whose water level is constantly rising at a slow rate. In order to reverse this process, expand the island and create a better environment, the player must perform environmentally friendly habits in real life. Sensors are used to detect the player's behavioral patterns and actions in real life. This data is then processed and the effect is actuated into the game world itself. If the player has performed some good habits/actions, the island will expand and the player will receive points in order to buy more products for the island. The aim of making the game was to teach young children environmentally good habits through the on screen tips and to encourage them in a fun and competitive environment to become better inhabitants of this planet.

As for the future work, several challenges exist in the current version of the game. First of all, we would like to utilize more types of sensory data to fit into more scenarios by combining different types of sensing results. For example, the challenge to turn off the AC before leaving home could be verified by first taking a picture of the thermostat, then using the GPS data to determine when the player has left home. This specific example could be very effective in changing people's habits since usually it is not that the users do not want to turn off the AC, but mostly they do not remember. Being asked to take a photo of the thermostat could serve as an excellent reminder. Also more interestingly, with the ability to measure users' real-life activities, the users' real-life data could be extremely valuable. Using augmented-reality gamification to acquire users' real-life data was also done in the very popular location based game Ingress [4]. Finally, the ultimate goal is to take this project beyond the research and actually release the game into the Google Play Store.

VI. References

[1] Harteveld, C., Sutherland, S.C., and Smith, G., "Design considerations for creating game-based social experiments" ACM Conference on Computer-Human Interaction Workshop, 2015.

[2] The Eco Ego official website: http://kizi.com/games/green-living-game, accessed August 30, 2015.

[3] Arduino Energy Monitoring Library https://github.com/openenergymonitor/EmonLib, accessed July 25, 2015.

[4] Why Google's Ingress game is a data gold mine, Technology News, 2012, https://www.newscientist.com/article/mg21628936-200-why-googles-ingress-game-is-a-data-gold-mine/, accessed August 30, 2015.