Interactive Climbing-nets for Dark Winter Playground in Sweden

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Abstract

Sweden is known for its long cold-dark winter. During this season, the number of children playing on the playground is decreasing. This condition is not suitable for children that need to be physically active and develop social interaction.

To support children body development while keeping them enjoying, we created an interactive climbing-nets that have playful lights combined with music-feedback to enliven the dark winter playground with an open-ended approach.

We developed the product using Arduino, flex sensor, RGB LEDs strips, and a speaker that we inserted into the transparent tubes. The tubes can be independently mounted to the traditional climbing-nets. To evaluate the project, we conducted user testing, followed by semi-structured interviews, to get feedback.

We highlighted the importance of material exploration that should be done from the beginning, the importance of idle mode as the invitation, and the combination of light and sound modality is more attractive for a design interactive.

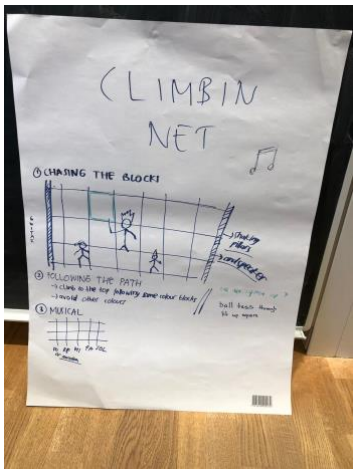

Figure 1. Focus Group Discussion Result

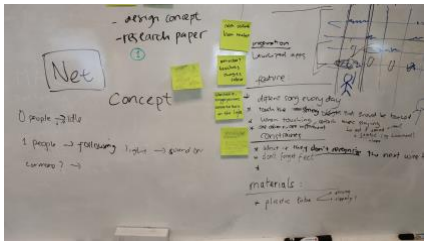

Figure 2. Brainstorming Second Phase

Author Keywords
Winter playground; interactive climbing-nets; light; music; open-ended; Arduino.

CSS Concepts
• Human-centered computing~Human computer interaction (HCI)

Introduction

Sweden, with its location in the north, is well known for its dark winter. Winter usually lasted for more than five months from around November/December to March/February every year [11]. During this season, the amount of sunlight is minimum. After school, children do not have many options to play outdoors. With this condition, most children will stay at home preferred to play with the computer. This condition makes them rarely exercise. However, outdoor play encouraged the children to have physical activity [2]. Children can be physically active playing and interacting with other children in the playground [3].

This research will try to find the opportunities and challenges in designing the playground that is suitable for the dark-winter condition while considering playfulness to support social interaction among children. The object study in designing winter playground is focused on the climbing-nets. We combined the traditional climbing nets in the playground with the technology by combining physical and social advantages to make the attractive outdoor playground[2]. We transformed the traditional climbing-nets into interactive climbing-nets with the physical interaction design approach.

In bringing this project, we used the combination of observation, focus group discussion and user interview as the research methodologies. The observation was conducted in the outdoor playground to see how the children were playing with climbing-nets when it is getting dark. We also conducted a semi-structured interview with the parents what they expected to have in the playground during winter. We used the information to do brainstorming by doing focus group discussion among the researchers to define which features that we should have in the climbing-nets (Figure 1, Figure 2). The project was evaluated by conducting the usability testing followed by semi-formal interviews at each of project development phase to gather user feedback.

Background

One of the most popular objects among children in the playground is a climbing-nets. During winter, the climbing-nets is seen as an uninteresting ride to play with less light. Climbing the nets in darkness is also dangerous that can cause children to fall. Falling is stated as the primary type of injury happened in the outdoor playground [10]. Based on these reasons, we intended to transform unattractive and unsafe climbing-nets into a new playful ride that can be used during winter.

Liljedahl et al. [7] added interactive light elements into climbing experiences in Digiwall. DigiWall was equipped with capacitive sensors that respond to hand and feet contact. LEDs inside the transparent areas light up when the interaction occurs. Their design inspired us to use transparent materials to put our component.

Figure 3. Launchpad Application [9]

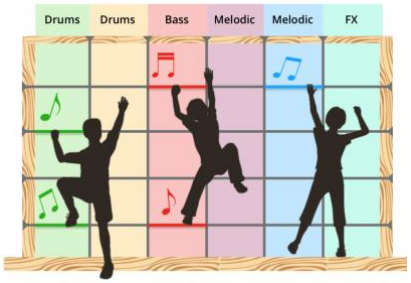

Figure 4. Design Concept

Another research about PlayGroundSound had applied music feedback in designing their game gestures [4]. The sound feedback associated with a wide variety of musical instruments with different pitches, tones, rhythms, and timbres. They used Max/MSP patch-based to interpret sound processing and used Arduino to process data from sensors and then sent it to Max/MSP with Wii Bluetooth remote.

These two research studies inspired us to design the climbing-nets to combine light and sound for the output modalities. Using two modalities are also useful to avoid error and ambiguity if one of the modalities has the problem. Besides, the visual and auditory modalities combination also performs better to attract children to play with [8].

Sturm et al. [12] identified five factors in designing a successful interactive playground. One of them is social interaction to allow the children to play without any help from adults. To implement the social interaction in the playground, we planned to design open-ended play for our climbing-nets. The open-ended game provides no rule in the game. The open-ended play has been recognized as able to create a multi-playing model that triggers children to physically active and have fantasy play and create their own game's rules [3]. We can use the modalities output from our climbing-nets to drive social interaction among children. For example, the climbing-nets can compose new mixed music when more than one player climbs the nets.

Result and Discussion

Design Concepts

We got inspiration from the Launchpad application in designing our interactive climbing-nets (Figure 3). Each column has a different light colour that helps children to identify the object in the darkness. This light will be ON when there is interaction occurred. Every column has a different melody, and each row has a different pitch level. Higher row produces a higher pitch. We transformed the interactive climbing-nets into a big music instrumental where children can play together to create the music while climbing (Figure 4). This climbing-nets, therefore, will trigger social interaction between players.

We created three models of interaction. The first was the idle mode when no interaction happened. Idle mode aims to inform potential players that the climbing-nets offers an uncommon thing to attract children to try it. The second is the single-player mode. When the interaction happened, LEDs will light up and certain music according to the location will be played. These two will stop when the interaction is over. The last is the multi-player interaction when more than one interaction happened at the same time and producing mixed music.

We identified two main challenges in designing interactive climbing-nets. The first challenge is avoiding the cacophony for multi-player model and producing nice music combination. The second challenge is finding suitable materials that will work in cold winter (expected to work <20C).

Development Process

At the beginning of development, we created a small prototype to visualize how the final climbing-net will look in a small dimension and to see whether the design concept is possible. We created a half-sphere shape structure to put climbing-nets from a piece of wood with

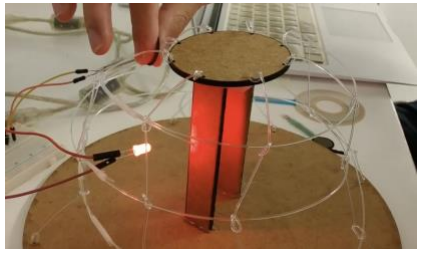

Figure 5. Small Prototyping

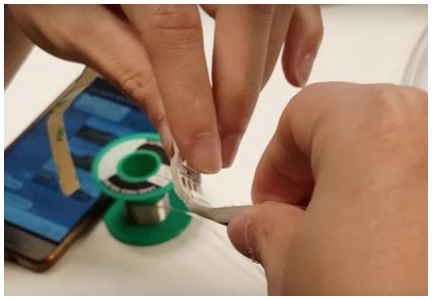

Figure 6. Flex Sensor Performance Testing

26 cm diameter base and 9 cm diameter top (Figure 5). The nets consist of 4 rows and eight columns created from the fishing string. We used Arduino Uno as the controller to read the output of the sensor and trigger the LEDs. We put the capacitive sensors that will respond to touching in the row of the structure. When the sensor is touched, the LED which was placed on the knot will light up. The small prototype was working correctly.

After proving that the design concept was feasible, we started exploring the materials for the final prototype. We chose Arduino Uno as the controller since it is easy to program with Arduino IDE and also has enough pin to connect all sensors and LEDs [1].

We chose the transparent tube with 10mm diameters as the packaging to protect electronic components from the extreme weather conditions[5]. With its flexibility characteristics, the tube will not limit the user movement while emitting the light from the LEDs. We decided to change the capacitive sensors since it will not be working in winter due to sensor affordance[5]. During winter, most people playing in the playground will use the gloves. The gloves from fabric materials cannot trigger the capacitive sensor. We explored three alternatives of replacement capacitive sensors: flex sensor; pressure resistor; button. We conducted the performance test on them and inserted them to our chosen tubes. The force sensor is not working well inside the nets while the button required high force to push them. Therefore, we decided to use the flex sensors (Figure 6). Flex sensor supports the bending but not very sensitive on small movement. Also, with its small width dimension, flex sensors can be inserted into the tube easily.

At a later step, we inserted RGB LED strips (WS2812b) to the tube. We programmed LED strips differently on each row with different colour set up. We connected the LED strips and sensors output with wires and connected them to Arduino Uno pins. We programmed the controller to read the bending sensor that will trigger the music and light up the LEDs. When more than one rows are bending together, the LEDs for those rows will light up and the music coming from each row will be mixed. We also programmed 16 random running individual LEDs to light up when there is no interaction occurs. These random LEDs will stop when the user starts interacting with the nets.

In the end, we created six individual rows climbing-nets containing the electronic components connected to other three tubes. We designed it that way so the bottom structure would be strong enough for climbing.

Evaluation

We evaluated the project by conducting user testing to see usability issues and potential improvements. In order to get continuous feedback for each development phase, we started doing the user testing from the small prototyping phase until the final project in the exhibition area.

In the beginning, we conducted a small user testing with the class participant of Physical Interaction and Design course in order to validate our design concept. We showcased our small prototype in the class, then participants came to see and test our product. Without describing how it works, the participants started to touch the capacitive sensor, and then the LED lighten up. Meanwhile, one of our team members acted as Wizard of Oz to push the button to play certain music since we

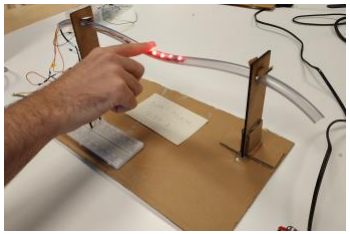

Figure 7. Second User Testing

Figure 8. Third User Testing (Outdoor Playground Testing)

Figure 9. Project Exhibition

were not finished implementing it yet. The participants told us that they understood the climbing-nets concept and could imagine how the finished product will be. We also got the technical feedback from the teacher that we had to explore another suitable sensor materials.

After conducting the first user testing, we improved the product based on the feedback. We changed the sensor from the capacitive sensor to the flex sensor, changing the LED Diode into RGB LED strips, and changing the strings into a transparent tube. With the same scenario, we exhibited our climbing-nets in Physical Interaction and Design class. We used one single tube that contains LED strips and flex sensors which connects to Arduino Uno. In this step, we already implemented music output connect to computer speaker. We hung up our tube to the cartons that made the foundation was not strong enough to accommodate the participants given force (Figure 7). During testing, we observed that the strength level of each person could be different. Hence, setting the threshold is a bit tricky to make sure this climbing-nets is working as expected. Therefore, we need to determine the sensor threshold before the installation.

In the next step, we brought our product to do user testing in a real outdoor playground. However, since winter still in a few months, we could not test our product with a real winter environment. Alternatively, we decided to go in a dark situation and tested it after sunset. Before testing, we have surveyed nearby playground that has the climbing-nets in Ekoparken Lekplats and measure the dimension as our product size references. We built two pieces of the human-scale prototypes that resembled the actual of climbing-nets that can be tied into the traditional climbing-nets. After installing our interactive climbing-nets (tied it up), we did calibration again to attain the correct threshold value. Our participants were six children around 5-8 years old.
They were playing at the playground and curious about what we were doing. After giving a brief explanation to the parents, the children agreed to climb our nets (Figure 8). In the beginning, only a few children climbed the nets. After that, some other children approaching and watching their friends actions and started to climb the nets. This behaviour is a more natural way to copy since learning how to play can be learned by watching[6].

We observed that at the beginning, the children did not understand what happened when they climbed up the nets. After they stepped their foot on the nets, the music started playing, and the LED lights up. At the second attempt, they tried to jump on the rope tried to step on different rows to see whether the music or the light colour would be different. Our fragile installation did not support their enthusiasm to play with our nets. After several times, the tube did not go back to the initial position. Therefore the music and LEDs kept going on. We figured it out that putting flexible tubes which tend to bend to the rope was not a right decision. For future work, we plan to change it to more flexible materials.
Getting feedback from the children participants was a bit difficult due to the language barrier, but the way they kept climbing, again and again, made us came with an assumption that they liked it. Their parents also told us that the children enjoyed it and could not wait for the installation.

In the end, we showcased our final prototype in the exhibition hall. We hung up our climbing-nets on the second-floor fences of the venue (Figure 9). We used this occasion as the last chance to gather the perspective from different user's backgrounds. Some of the visitors

are children, students from different programs, teachers, and academic staff.

Unlike a real playground, the structure in the exhibition to hang the prototype was not strong enough to step on it. Therefore, we just encouraged these users to interact with their hands instead of climbing. After conducting the interviews, we got some useful insights:

- Most of them came to our booth, attracted by the idle mode that we set up.
- Some of the visitors curious to find out our interactive climbing-nets after overheard the music playing when someone else interacted with it.
- The children less than five years old were not free to explore each row of our climbing-nets due to installation a bit higher for them.
- Some students (mostly come from the different program) thought that they should catch the running LEDs (random idle mode) to trigger the sound. We realized that not all people understand our design concept.
- Adults said that they liked our climbing-nets and treated our climbing-nets as the massive instrumental music that they could play alone or together.

Conclusion

In the end, we have already built our interactive climbing-nets following our concept (idle mode, single-player, and multi-player). We built six rows of the climbing-nets from flex sensor, and RGB LED strips that connected to Arduino Uno and external speaker. These components are placed into a 10mm diameter of flexible and transparent tubes. The interaction will trigger the Arduino to turn the LEDs strips ON and activate the dedicated music.

Even though the testing was not performed in the real winter situation, we still got some key learning from this project:

1. Material exploration is essential. Material exploration should be done earlier since it will affect the whole development process [5]. In the beginning, we built a small-scale prototype using used capacitive sensors. However, it would not work if interaction points are covered with fabrics. We should explore other sensors options from the beginning; therefore, the development pace will be faster. In another case, we found out that the tube could not go back to the initial position after being stepped on many times when performing outdoor testing. Searching the elastic and transparent tube should be done for future improvement. Therefore, we do not need to calibrate it again after using it several times.
2. The idle mode plays a significant role, inviting people to play. Without implementing this idle mode, our climbing-nets would be just an ordinary darknet that was not attractive enough.
3. The importance of music integrated with climbing-nets to support the interactivity. People kept coming to our exhibition booth when they overheard the music produced by someone else is playing with our climbing-nets. The users were also interested in the mix music produced when playing alone or together.

Acknowledgement

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