Design and Development of a Robot Companion Suitable to be used for Clown Therapy in Hospital

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1. Introduction

In the last 30 years, it becomes common that in children ward in the hospital there are some clown in order to bring fun to those ill kids. Indeed, it has been shown that by using humor the clown can help the children to gain healthy quickly and accept the hospital treatment, since the contact with the clown helps to avoid distress and negative consequences on the behavioral, emotional, cognitive and educational development.[1].

This activity is known as Clown Therapy which represents a peculiar way of using humor in order to promote people's well-being by implementing clown techniques derived from the circus world to contexts of illness [1].

The aim is, through humor, promote a more relaxed situation in an unfamiliar condition which helps in decreasing children's fear of separation from parents and home environment, as well as decrease the sensation of loss of control, to face unfamiliar routines, surgical instruments, and hospital procedures. [2].

The Clown therapy officially started in 1986 when, simultaneously in Canada and USA, Karen Ridd and Michael Christensen began the practice of clown in broad pediatric hospitals. However, Ridd and Christensen had two different approaches to the way clowns work in hospital: the solo therapeutic clown and clown doctors who work in pairs.

Therefore, could be interesting to introduce some device that allow an improvement to the clown performance, making it more effective, surprising, and a novelty for children.

Our work it is then placed in the attempt to develop a new robot companion which can be successfully used in the hospital environment. Moreover, the idea was that the clown can perform the role of the "white clown" and use the robot companion as the role of "August". Accordingly to Christensen approach the "white clown" represents the rational voice of reason and the orderly decision maker and the "August" represent an emotional character who is also the problem maker [1].

There was many challenges faced such as the development of some functionality taking into account that the robot is not able to move by itself, the personality of the robot and how much control of the robot companion the clown had to have in order to make a good performance.

Other studies should be done in order to manage problems such as sterilisation, wearability and actual success of the robot approach to clown therapy.

2. The Clown Therapy

2.1. The role of the clown

The practice of the Clown Therapy officially date from 1986, however there is studies which compare the role of the clown on the hospital to the role of the ancient shamans [3].

At the same time the Clown doctor role is not to replace the traditional physician. The clown has the mission to transform the hospital environment in a friendlier and psychologically comforting environment. Whereas the hospital is not primarily designed for people to feel comfortable, especially children, but rather to be efficient in the combat and treatment of several disease and conditions. This design focused on the efficiency makes the patients feel more and more uncomfortable, with a great amount

of emotional burden while handling with a potential stressful situation related with the experience of being in need of medical care and in a perceived hostile environment.
Therefore the Clown doctors' act, through humor, bring comfort and relief to the patients and hospital staff. They act to treat the individual's illness experience itself rather than treat the disease, which is the function performed by the physician. In a certain way the role of the Clown doctor is such like to the alternative medicine in the sense of have the concerning with the individual as a whole, however they always work together with physicians and even psychologists. Therefore the practice of the Clown Therapy is better describe as complementary or additive medicine [3].

2.2. The training of the clown

The training to become a Clown doctor comprises both theorical and practical aspects. It is necessary to learn about artistic disciplines such as: clowning technique, pantomime, theatrical improvisation, and team working skill, principles of common prestidigitation and juggling. Furthermore the candidate must study subjects such as gelotology, psychology, communication, anthropology, social science and also learn about the basics of the hospital routine and related subjects, for instace the basic notions on diseases, hospital rules, privacy rules, self-care routine (grooming, bathing, dressing, toileting, eating) [1].
The candidate must possess good interpersonal skills, self-care and responsibility.
The practical experience is gained by taking part to role play and by practicing within the clinical setting [1]. Later, usually, an expert clown doctor follow the candidate as tutor by providing ongoing supervision and monitoring the psychological attitude and correcting possible mistakes.

2.3. The performance

The Clown doctor use several techniques in their performance. It goes from theatrical techniques to the use of musical instruments. They also make use of different tools to improve the performance such as, as mentioned before, musical instruments, juggling balls, balloons that can be folded to animals and the physician instruments itself in order to joke with the hospital routine.
In this context we asked ourselves how to insert a robot companion as a tool to improve the performance and bring novelty and amaze even more the children. A robot that appeared to have its own personality but still under the control of the clown.

3. The Design Proccess

With the goal to develop a robot companion to improve the performance of the clown doctor we first needed to decide how to solve two main issues even before to start the first sketches, this issues are related to how the robot is perceived by the performer and his audience:
How to integrate the robot companion movement to the clown's performance?
How to represent the personality of the companion without making the outcome of the performance predictable?

3.1. Wearable

In order to choose how to integrate the robot's movement to the clown's movement during the performance we analyze the following options:
1) A complex system of sensors and movement where the robot would track the clown's position and would take the decision on how to move accordingly to the pre-programed performance.
2) The robot could not move by itself, however it should be equipped with sensors to track the clown's position and react to some specific actions during the presentation. It should be possible for the robot to rotate to give the impression that it is always facing the main subject of the performance.
3) The clown could carry the robot like a puppet in his hand or in his shoulder.
4) The robot could be part of the clown's clothes.

The first option is clearly the most complicated between the four, because it is necessary to develop a complex system of sensors and movement which should be capable of track the position of clown and react with enough speed and spontaneity not to make the performance more difficult. Perhaps could be necessary for the clown to program some acts before the performance in order to interact with the robot companion which would increase even more the complexity for the development.

However a second option could be to have a fixed position on the room for the robot in the beginning of the performance, allowing only the rotation movement, in this case the choreography and actions of the clown would be around the machine. Though this is an option which limits the clown's performance and do not reinforces the interaction between the clown doctor and the children or the audience, but, instead, reinforces the interaction between the clown and robot itself.
In the other hand eliminating the necessity of the robot's movement though the room could be really positive since it should reduce the complexity of the development while diminishing the consumption of energy. However without movement the robot could become boring for the performance. To solve this problem we could build the robot similar to a ventriloquist doll but again it could limit the performance since the clown should carry the doll exactly like in a ventriloquism performance and as a major downside the interaction between the two, clown and companion, would be more similar to a relation between human and object than human and companion, because in the moment the clown doctor needed to use both hands for another trick, such as a magic one, he would put the robot aside.
Keeping in mind the importance for the clown's movement freedom we choose to follow a wearable approach to develop the robot. Even though being a wearable the robot should have a behavior in order to exist the distinction between the individual dressing the device and the robot as a companion.

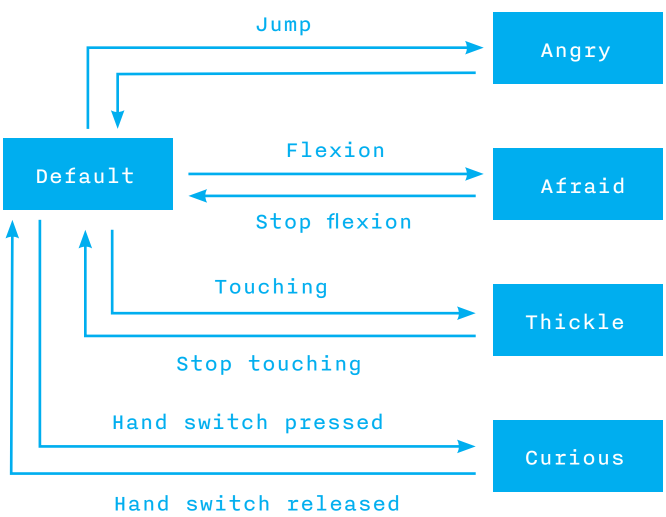

Fig. 1 Framework of behaviour

3.2. First prototype

Our first prototype was made up two main part: an internal rigid structure that contains the hardware components and gives support to the actuators, and an external part that hides all the wires and electronic devices. We start to design the face and the interactions. Eyes movements: an LED was placed on the top of servo shaft in order to make it move. All this structure was placed in a see-through semi-sphere which came out from the coat. Despite the goodness of that solution, it was aesthetically weird and no efficient from an interactive point of view. Mouth: made by LED strips, but they were difficult to shape. Children interaction with the robot: some magnets were used in order to change the behaviour of the robot by closing the circuit. They were not implemented because de interaction was too strained and limited to the magnets. Therefore we rethinks our project.

Fig. 2 First prototype: internal structure

Fig. 3 First prototype: external structure

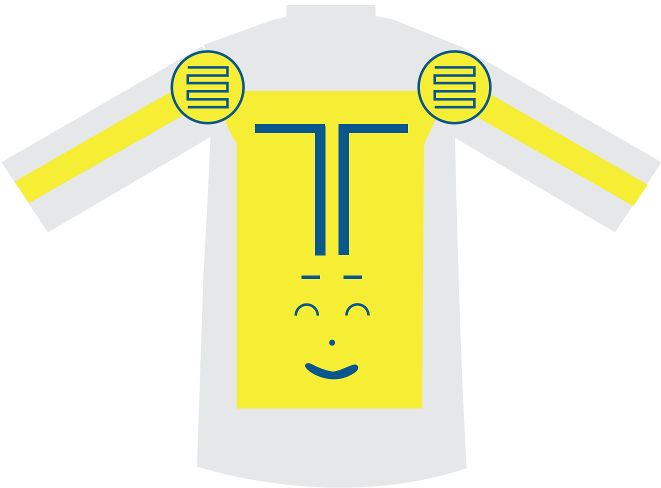

Fig. 4 Robot drawing

3.3. Expression and Emotion

In order to imbue the robot companion with personality we choose and approach focused on having a set of emotions trigged by the clown's performance. Therefore we defined four basic emotional states: Angry, Afraid, Joy (Tickle) and Curious. We call them basic emotional states for the convenience and not for being considered basic emotions by the psychology, however defining them as emotional states it was a path to imbue the robot with a personality that can adapt to the needs of the clown's performance.

For the development it was needed to decide a trigger for each representation of emotion in order to define a specific action that could be captured by some sensors and translated in a proper output with the programmed emotion.

The triggers for each emotion are:

- The Clown should jump to activate the Angry behavior;
- The Clown should bow to activate the Afraid behavior;
- Touch the clown's shoulder to activate the Tickle behavior;
- The clown's touch activate the Curious behavior

With this strategy of triggers and emotions/behaviors we hope to provide enough autonomy for the clown doctor to plan his performance and at the same time maintain the ability of improvisation, since the behavior of the robot companion should not be preset for a specific performance.

3.4. Concept development

After we had the basic concept clear and also decided how to keep a relevant interaction between the robot and the clown, we started to work in the esthetics of the wearable.

We choose more neutral fabric colors to remember the usual outfit used by clown doctors, but at the same time we choose yellow and blue to cover the robot and make it look more cheerful.

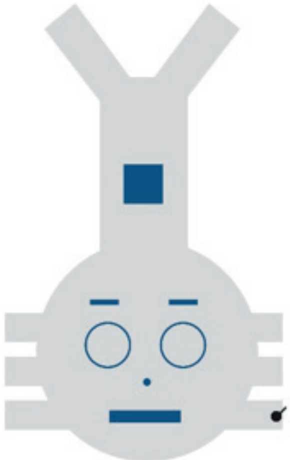

Fig. 5. Structure to hold the hardware components

To represent the emotion of the robot we decide to use sounds and a "face" with LED eyes and a mouth. The face, which is located on the front of the outfit, is important to represent the basic emotion and also to delineate and reinforces the separation between the user and the robot.

In order to make more comfortable and convenient for the user we decide to build an inner structure where the main hardware components could be attached and therefore allow a greater freedom of movement.

3.5. Production

For the production of the suit we used a combination of cotton/polyester mix and polyester fabrics both for their breathable and strong qualities. Both qualities are important for the project in order to bear the weight of the electronic components at the same time that allow enough air flow.

To sew the fabrics together we used polyester thread. We also used metal conductive thread at the tou-

ch sensor point obviously for its ability to conduct electricity.
For the construction we adapted the raglan sleeve to envelope the whole upper chest and shoulder area in order for us to efficiently create two layers at this particular point of the body with the objective to hide the wiring of the robotic face. This part of the design was also done to aesthetically fit the concept.
Concerning the touch sensor pads, they were inserted into the top layer of the sleeves without creating a whole in the sleeve fabric in order to maintain the shape at the sleeve and create enough negative space behind the sensor wire to allow it to work properly. Since the sensor wire could detect the user body data we needed the negative space for the sensor to be able to capture only the viewer's touch data.
The inner 'frame' of the garment was to center the electronics to the body of user to enable maximum maneuverability.
The chipboard's were placed in breathable pouches that are suspended from the shoulder line to maintain maximum comfort. We also inserted a box like structure into the outer layer of the garment at this point so that the two layers of the garment moved harmoniously. We also created an air vent at the top of the box structure in order to channel the heat created by the chipboard away from the body.

3.6. Producing

In order to built the electronic part, two board were realized using the 'Press & Peel' technic using the Eagle Cad Software.

4. Development

For the development we used the electronics prototyping platform Arduino. For being open-source and with a huge developers community actively involved Arduino has plenty possibilities and resources to build our project.
In order to have enough spontaneity for the clown doctor's performance we defined four basic behaviors for the robot each one of them activated by a different trigger.
The triggers are tracked by the sensors while the output are behaviors which consist in the combination of sounds, the blinking of LEDs which represents the eyes of the robot face and the movement of

1. Print the Cad draw on photographic paper, iron it on the copper layer then peel the paper with the help of water

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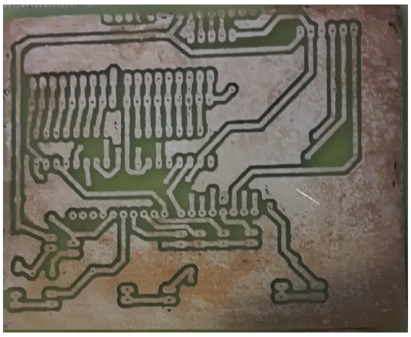

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5. Holing, soldering and wiring

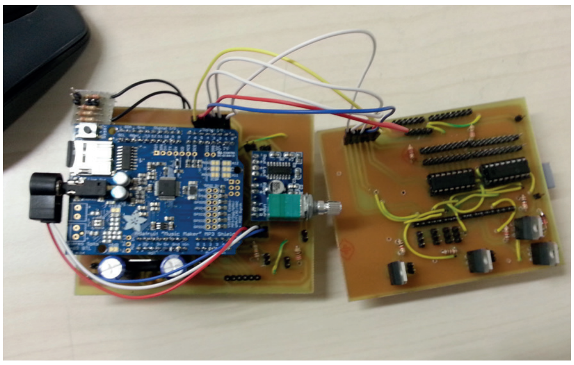

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Fig. 6-9. Press and Peel

the mouth, eyebrow and antennas.
In order to develop the emotional state, we firstly analyze which kind of sensor and which principle could be implemented.
We need to recognize: jump, tilt, touch and colors.
For jump and tilt measurement, a triassial accelerometer is suitable. Indeed, it gives the measurement of the forces applied in vertical and horizontal direction. When accelerometer are used, some calibration is need. Therefore, it was measure the gravity force in the three direction and on the six verses. Those values were used to compute a linear fitting for each direction.
Jump detection: the module of the acceleration will be equal to the gravity acceleration when no forces are applied.
Fig. 10 show that the module will increase when the jump start and decrease when the person is at the edge of its jump. Then, the module will increase again once the ground is touched. Therefore, it would be enough to sample the 3 axes, evaluate the module and recognized as jump any situation when the module of forces applied on the accelerometer go over and below two threshold: it was find that 3 m/s2 and 15 m/s2 are respectively the low and high threshold.
Tilt sensing: in static condition, the only force measured by the device is the gravity. Because it doesn't change its direction, it is possible to estimate the angle of inclination to the horizon. The same methodology is used in dynamic condition even though other force may be applied biasing the measure. Therefore, the estimation works well for slow movements. A solution could be to uses a combination of gyroscope and accelerometer. However, for the current application only the accelerometer with a moving average filtering were applied. Following the equation for the angle estimation:

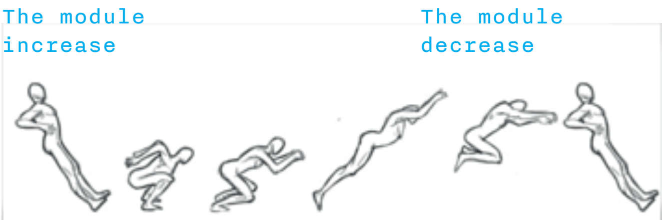

Fig. 10. Jump

$$\theta = \arctan\left(\frac{A_x}{\sqrt{A_y^2 + A_z^2}}\right)$$

$$\varphi = \arctan\left(\frac{A_y}{\sqrt{A_x^2 + A_z^2}}\right)$$

$$\Phi = \arctan\left(\frac{A_z}{\sqrt{A_x^2 + A_y^2}}\right)$$

Fig. 11. Angle evaluation

As touch sensing, the cap-sensing principle was applied.
In Fig.12 a RC circuit is show. When a tension in applied to this easy circuit, a delay equals to τ= RC(t) arises. Conductive textile threads was used and were placed as in Fig.13. The resistance does not change significantly.
This way, if the capacity of the circuit is 0, therefore τ =0. When someone touches it, the capacity changes and, therefore, a delay between read and write pin appear. In order to implemented it, was chosen to apply 5 V for 1 ms: if the tension on the read pin was 0 V, it mean that someone was touching it and that the delay increase.

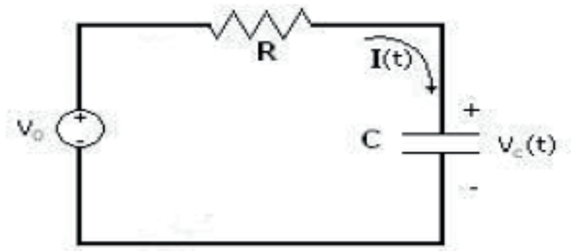

Fig. 12. RC circuit

In order to do colors sensing several strategies exits. All of these, consist in illuminating with a light (i.e. a LED) and measuring with a proper sensor the response for red, blue and green. A suitable way could be to use a white light and three photodiodes sensible to red, green and blue or using a sequence of red, green and blue illumination and sensing with one

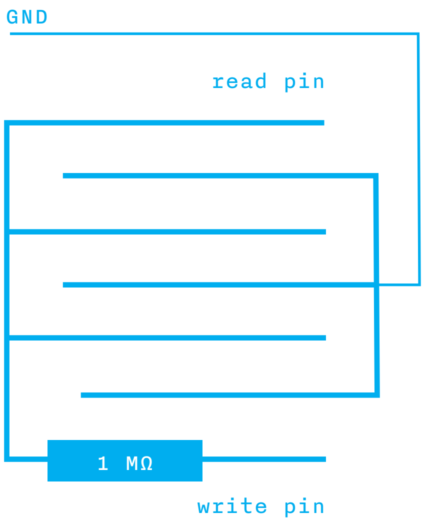

Fig. 13. Conductive textile thread

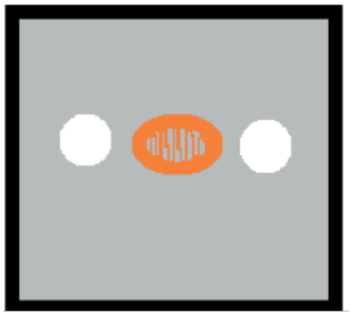

Fig. 14. Color sensor

LDR. As we did not have enough pins of analogical input, we choose to use the latter possibilities. We built the sensor at home. The principle of the sensor is that the LDR have a similar response to color as the human eye, therefore it could be used to senses color.
Pseudo-code:

- Switch on red LED;
- Read CdS photocell voltage and switch off red LED;
- Switch on grenn LED;
- Read CdS photocell voltage and switch off green LED
- Switch on blue LED;
- Read CdS photocell voltage and switch off blue LED
- Check what colour match the three voltage read

However, the situation is not that easy and a calibration phase was needed in order to evaluate the range of the colours.
As written above, those sensors were used to command some behaviour: movement of the mouth, eyebrows, antenna, eye illumination, strips led illumination on shoulder and music. Therefore, servomotors were used for the mouth, eyebrows and antenna. A Mp3 Shield with an amplifier and two 3 Ohm speakers were used. Two shift registers are used to decide the eye illumination and power MOSFET transistor were used to command the two led strips.

4.1. Components

We use the following components:

- 2 Arduino Uno
- 1 Mp3 shield Adafruit
- 1 Audio amplifier
- 1 accelerometer GY-61 ADXL335 Module
- 1 switch
- 2 shift-register 74hc595
- 3 servo-motor
- 1 color sensor: homemade using a LDR, two LED RGB putted in a black-box
- 2 LED strips rgb IP65
- 3 power MOSFET transistor
- 32 LED

In order to develop the eyes, the speakers with a properly shaped PCB with 16 blue LEDS were putted together for each eye. Each LED is connected to GND and to a pin of the 16-bit (two 8-bit shift register) shift register.
By using the shiftout() method in Arduino those were controlled with only three pins instead of 32.
Those components were properly welded on the PCB printed and the firmware shown in Fig.15

5. Conclusion

An interview with a user was performed in order to see how usefull and interesting is this new tool and if there are any limitation no considered. The clown was Francesca mercurio from Sorridimi Onlus who performs clown therapy in hospitals. From a clown point of view, the tool is interesting as it gives the possibilities to have more interaction with other clown and with the patient if their condition are good. However, the clown underlines the need to have more relaxing music and sound, and

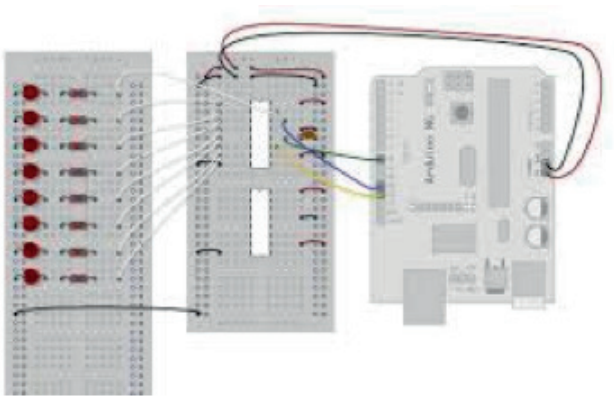

Fig. 15. Eyes schematic

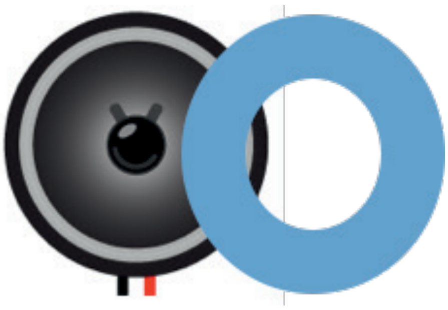

Fig. 16. Eyes: Audio amplifier and LED

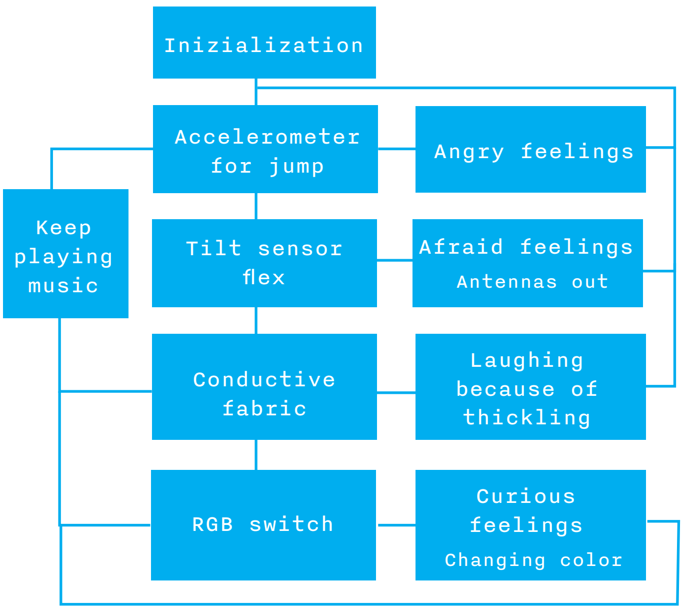

Fig. 17. Firmware flowchart

pehamps some switch in order to choose different kind of music with different patients. Despite the interest that the clown shows for our product, she underline the need to have an easy to wear coath and a washable device. For former needs, we think that a good idea is to rethink the harware as follow. Even though the machine seems to offer good performance, some development might be useful in order to enrich its functionality, user-friendly and reliability.

1) Hardware miniaturization: a smaller hardware would make the robot more wareble. Therefore, a smaller microcontroller, like the PSoC 3 from the cypress, and a smaller Mp3 shield, as the one shown in the Fig. 18 could offer a good improvements.

2) Using real RGB LED strips in oder to really mimic color: at the moment the strips of LED are not real rgb. Therefore, using those strips sould offer the chance to do research in the uses of more colors.

3) Buying a more accurate color sensor: unfortunately, if more colors want to be used, a more accurate color sensor, like the one in Fig. 19 from Adafruit is suitable.

4) Finding solutions to reduce the number of wires: the wires are a problem from a design point of view, from an engineering point of view and from a safe point of view. Reducing its number, for example by

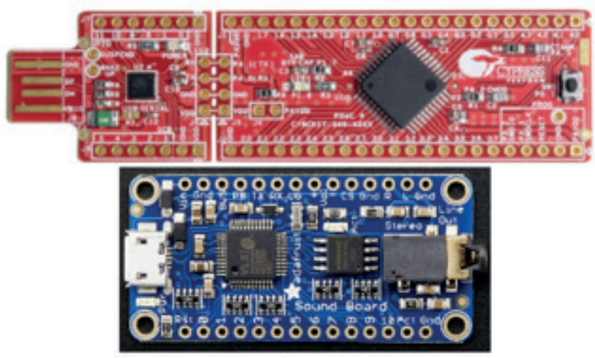

Fig. 18. Smaller Hardware

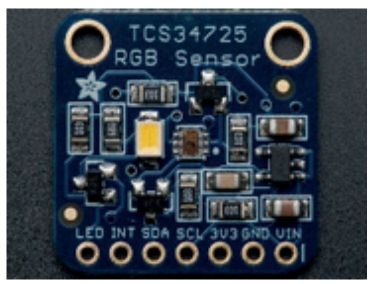

Fig. 19. Color sensor

deallocating the electronic hardware or using digital sensor and/or actuator instead of analogical ones, will make the device more wearable, better looking and safer.

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