Emotion Sensing

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DEP 304 | Industry Experience

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Introduction

Emotions form an integral part of all our lives. It forms the basis to what we express, and how we express it. For example, let us take happiness. Happiness can either make us smile or jump with joy. These motor reactions are governed by the amount of that emotion (happiness) that we feel. This amount also elicits a host of reactions within our body that allow for its expression. Physiological changes in the body occur, such as increasing the rate of beating of the heart and the release of endorphins, dopamine and serotonin amongst a host of other hormones. These complex changes influence how we learn, the decisions we make everyday, how we connect with one another, and our health and well being.

With the onset of technology, we are spending more and more of our lives tethered to devices connected to the internet. This gives us an impression of being connected to one another all the time. What this also does is reduce the amount of time we spend with each other and as a result, the amount of emotions we externalise. This lack of externalisation of emotions affects our interpersonal relationships with the people around us, more so with children. But the lack of externalisation doesn't stop the emotions from bubbling day in day out. This, at times, leads one to act out in particular situations, which might seem irrational. It becomes critical to understand what, when and where these triggers are caused and help the individual to cope with these triggers. This is where emotion sensing technologies can play a significant role in improving our health and well being.

Introduction to Philips Healthcare

Philips healthcare focuses on three driving principles which are:

Humanizing Technology
When technology is natural to use and delightful to experience it becomes a liberating factor that enriches people's lives, stimulates their senses and extends their capabilities. We always aim to bridge the gap between human interaction and cutting-edge innovation.

Holistic Care
Design for entire care ecosystems, bringing personal and professional healthcare ever closer to each other. Shake up existing paradigms and ways of delivering care to offer experiences superior to those currently available. **Always think and act with sustainability and durability in mind.**

Radical Empathy
People are unique, complex, multi-faceted and ever-changing - so we put ourselves in their shoes to truly understand their functional, emotional and aspirational needs. By connecting with them on a fundamental level we help them maximise their potential.

Philips healthcare continuum

With growing focus on healthy living and prevention, people are looking for ways to proactively monitor and manage their health both in home and community settings. Healthcare is now no more limited to hospitals but is considered as a continuous continuum that spans in every part of a person's life journey. There is great value in more integrated forms of healthcare which is connected and supports faster diagnosis and treatment at any time. Visualising healthcare as a continuum enables unlocking gains and efficiency and drive innovations that help deliver a good patient experience, improved healthcare outcomes, affordable cost of care and improved work life of care providers.

The value of a patient is created over the full cycle of care - from the pre-hospital phase, their time in hospital, as they prepare to go home and recovery period at home.

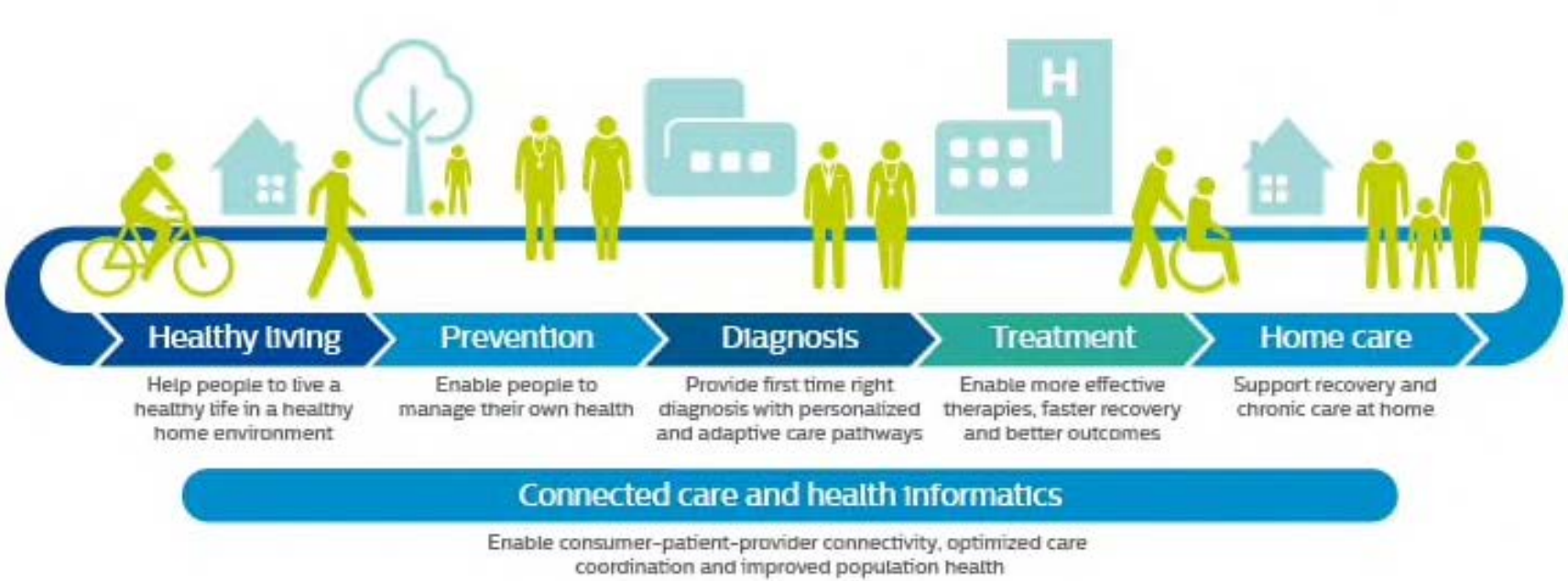


Image Source: https://www.philips.com/a-w/about/company/our-strategy/our-strategic-focus.html

Before getting into sensing emotions, we should understand what emotions are.

What Are Emotions?

"Emotions are episodes of interrelated, synchronised changes in the state of the body to internal or external stimuli inducing events relevant to the major concerns of the individual."

They produce physiological, behavioural and cognitive changes. The original role of emotions was to motivate adaptive changes in humans for survival. Now, their primary use is to add depth to the words we speak.

According to Klaus Rainer Scherer, there are five crucial components that coordinate and synchronise to enable us to experience emotions. These are:

Cognitive appraisal· provides an evaluation of events and objects.

Bodily symptoms· the physiological component of emotional experience.

Action tendencies· a motivational component for the preparation and direction of motor responses.

Expression· facial and vocal expression almost always accompanies an emotional state to communicate reaction and intention of actions.

Feelings· the subjective experience of emotional state once it has occurred.

Emotion Function	*Organismic Function*	*Organismic Response*
Subjective Feelings	Monitoring	Sadness, Happiness, Gratitude
Action Tendencies	Motivation	Weeping, Jumping up and down, Thanking
Appraisal	Meaning making	I lost something, I got a gift!, Passed a test
Motor Activity	Communication	Crying, Smiling, Raising chin
Physiological	Support	Change in pulse, Blood flow, Brain activity

These are the five subsystems of the body that help us experience emotions. They help us make sense of the correlation between what we express and what we feel.

Sensing Emotions

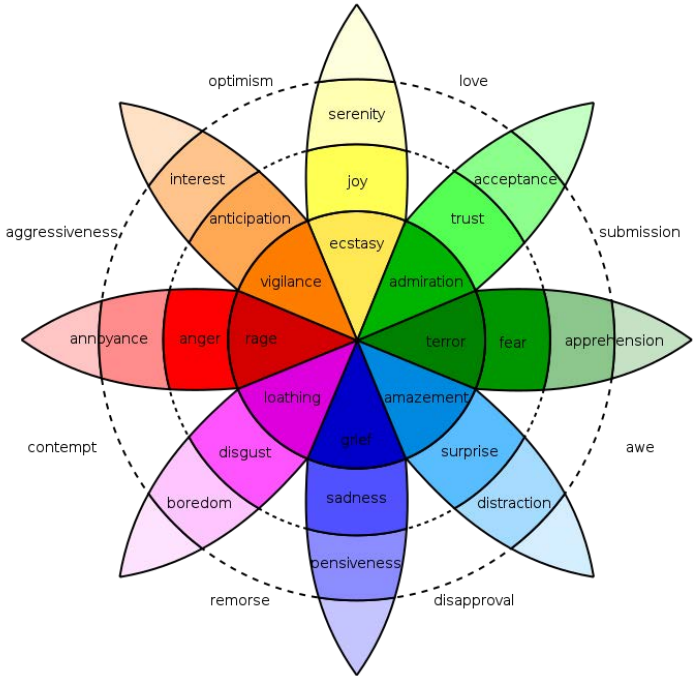
Humans have this extraordinary gift. We can differentiate a smile from a smirk, tears of joy from tears of despair, pick up on subtle variations of expressions and make profound meaning from them.

Let's take the example of perceiving emotions through vision. Data is gathered from the facial expressions of the individual, his/her body posture, the environment or the context in which we are attempting to perceive the emotions, and all of this is processed cognitively in order to interpret what we are seeing.

In addition, we are able to understand cultures and the numerous ways in which the same emotion can be expressed. Eyes and eye brows are used (upper face) is where the primary emotions are detected in the eastern cultures, whereas, mouth and nose (lower face), through verbal expression, is how primary emotions are detected in western cultures.

This is the data we get just from our eyes. We are able to perceive emotions even through auditory, olfactory, and physiological sensory processes. The amount of information processed is not something technology of the present can compete with. Given the complexity of the task at hand, it becomes a necessity to break down emotions into simpler and more discrete units.

Robert Plutchik developed a system to classify emotions into discrete, universally recognised expressions. This was called the Wheel of Emotions. According to the Wheel, there are eight primary emotions grouped on a positive or negative basis. As with colours, these primary emotions blend to give the full spectrum of emotions.

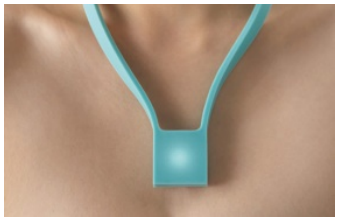


Plutchik's wheel is forms the basis for our approach to this project.

The Landscape:

Existing Products

A study of existing products was done to understand the possibilities of emotion sensing using current technology.



1. Philips Vibe

A necklace with multiple sensors fit in to detect emotions. This is then displayed on the device to help communicate to wearers what emotion one is feeling at any given moment.

2. Philips Rationalizer

The "Rationalizer" bracelet system detects stress levels and displays a warning to help day-traders avoid making hasty decisions. The product detects fear while making transactions to determine stress levels.

3. Anki Cozmo

Cozmo is a game-playing machine. That helps children and teenagers add to a new addition of a social contours. It helps kids learn, play games as well as act as an emotional support to help them feel better everyday.

4. Softbank Pepper

Based on your voice, the expression on your face, your body movements and the words you use, Pepper will interpret your emotion and offer appropriate content to help you feel better. He will also respond personally to the mood of the moment, expressing himself through the colour of his eyes, his tablet or his tone of voice.

Existing Sensors

A secondary research was done to see what sensors were being used to detect emotions. They could be categorised in three segments.

1. *Facial Recognition sensors:* Basically cameras. They look for expressions on the face. Facial Action Coding Systems, a system where each muscle movement has been mapped to a certain expression, is used to identify expressions that arise from certain emotions. Emotions such as Anger, Joy, Disgust, Engagement, can be detected along with it being able to tell if an expression was positive or negative in its valence.

2. *Skin based sensors:* These sensors detect physiological changes in the body in response to emotions we feel. They detect change in temperature, galvanic resistance, pulse rate, etc.

3. *Speech Detection sensors:* Microphones with complex algorithms running in the background. Emotional speech processing technologies recognise the user's emotional state using computational analysis of speech features. Vocal parameters and prosodic features such as pitch variables and speech rate can be analysed through pattern recognition techniques.

Based on Robert Plutchik's eight basic emotions, physiological reactions of the body in response to these emotions were mapped. This is done in order to pick up on emotions through biomedical sensors that can track a person's well being throughout the day without being too invasive in the person's life. Also, physiological responses of the body to the various emotions are near impossible to fake. In addition to biomedical sensors, some basic gestures that would be normally associated with certain emotions could be recognised through sensors we find around us. For example, when a person is angry, they tend to grip objects forcefully. This is something that could be identified via Force Sensors.

But these physiological reactions are subtle and quick. For example, let's take a look at anger and fear.

Anger: Muscles tense up, heart rate increases, rate of breathing increases, sweat glands release sweat, blood rushes to the face, electrical conductance of the skin is high.

Fear: Muscles tense up, heart rate increases, rate of breathing increases, sweat glands release sweat, blood rushes to the face, electrical conductance of the skin is low.

The physiological reactions are almost exactly the same but for the difference in the conductivity of the skin. This makes it very difficult for modern sensors to detect the emotions accurately. But a multimodal approach to this problem can give a more accurate answer as towhead emotions a person is likely to be feeling.

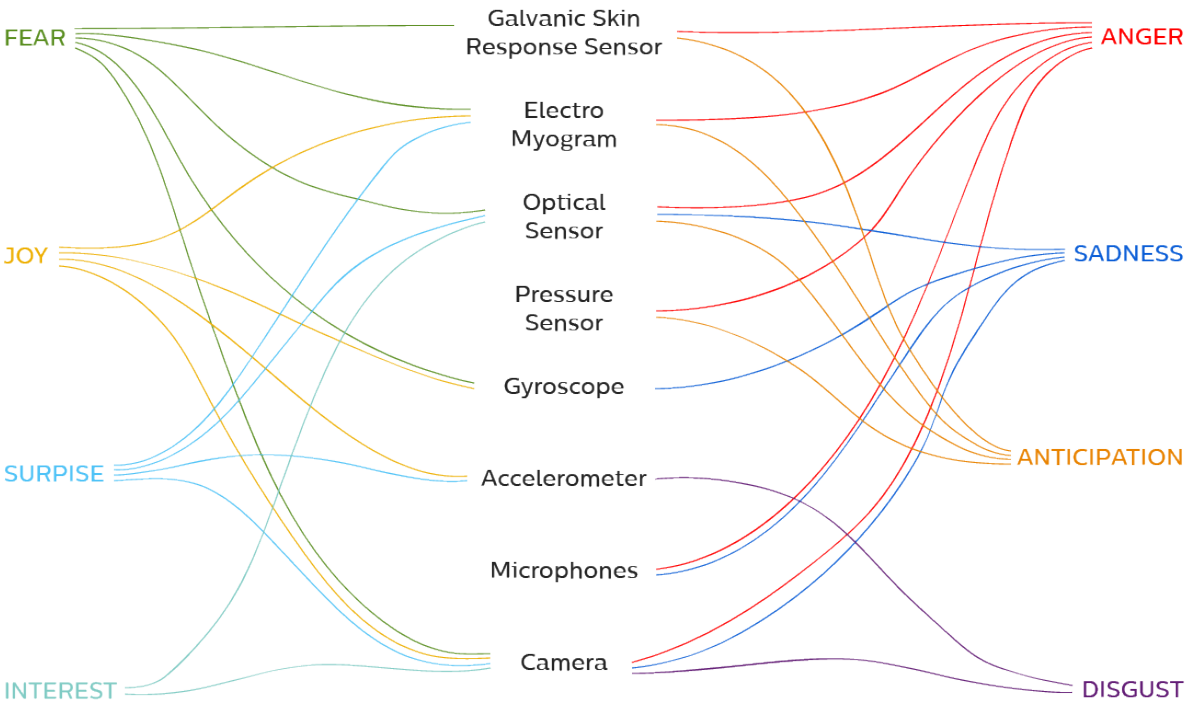
On the next page, I have mapped the various physiological reactions of the body in response to the emotions and what sensors can detect these reactions. Using multiple sensors, we will able to gather enough information to say with a degree of certainty that an individual is experiencing one of the eight emotions as their primary emotion.

Muscles tense up
Heart rate increases
Rate of breathing increases
Start sweating
Blood rushes to face
Electrical conductance of skin is low

Warmth across whole body
Increase in Dopamine, Serotonin, Adrenaline
Smiling (activation of action unit 12)
Muscles ease

Eye brows raised
Horizontal wrinkles across forehead
Pupil dilation
Tenseness, especially in neck muscles

Heart rate increases
Electrical conductance of skin is high
Blood rushes to face



Muscles tense up
Heart rate increases
Rate of breathing increases
Start sweating
Blood rushes to face
Electrical conductance of skin is high

Chest Pain
Tears well up
Crying
Temperature drops
Numbness

Muscles tense in anticipation
Heart rate increases
Rate of breathing increases
Blood rushes to face
Electrical conductance of skin is high
More subtle when compared with Anger

Narrow brows
Curled upper lips
Protruding tongue

The Problem Statement

After the secondary research, possible areas for emotion sensing to intervene were explored. From mother-child relationships to senior citizen care, we explored possibilities everywhere.

A few hours into throwing ideas onto the wall, an affinity mapping was done. The ideas could broadly be categorised as:

Mother & Childcare

Age

Environments

Relationships

Personal Health

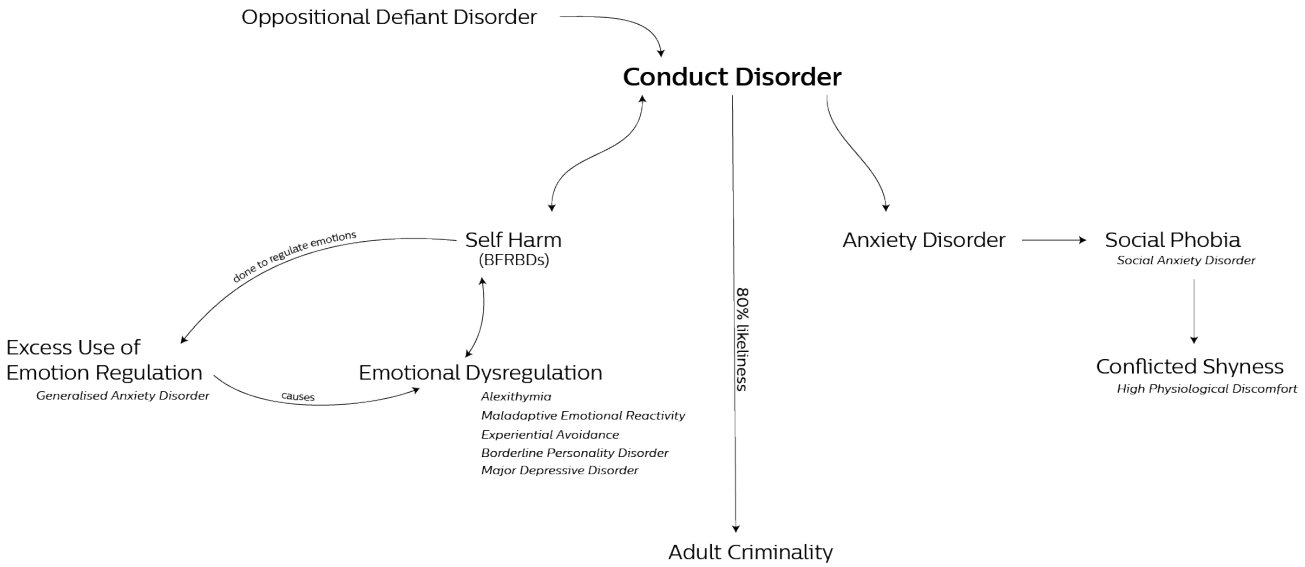
Safety

Of these areas, we chose to go ahead with Mother and Child Care.

We decided to tackle disorders related to children. This would be done with the help of the parents and would strengthen the relationship between a child and its parents. Three areas interested us.

1. Conduct disorder
2. Eating disorder
3. Social Anxiety disorder

We looked at the the pain points related these areas. Out of the three, Conduct disorder seemed to be the one where the most could be gained by using emotion sensing technologies.



Symptoms of Conduct Disorder:

- Children bully, they show traits of aggressive, dominating and impulsive behaviour
- They lack attention and feel neglect from parents
- They're copying others
- They lack skills
- They want independence
- They can’t control their emotions
- They want power and control
- They might have underlying mental health issues
- Bullying can have a wide spectrum of effects on a student including anger, depression, stress and suicide

These reasons compelled us to go with conduct disorder as an area of intervention for emotion sensing technologies to be used. The Problem Statement now stood

“Detect and analyse early signs of Conduct Disorder through Emotion Sensing technologies and IoT”

We also decided to focus on increasing Parent-child bonding and helping the child control his/her aggression.

Persona

A persona was created based on clinical case studies on children suffering from Conduct Disorder. Since the goal was to detect and analyse *early* signs of Conduct Disorder, we decided to make our persona an eight year old child, an age at which the first signs of the disorder are seen.

Rahul Shah

8 year old

Studies in the third grade

Loves playing sports and is very good at most of them

Comes from a well to do family

Both parents are working and don't have much time for him

Is weak in Hindi and English

Hasn't developed his communication skills

Journey Mapping

This was done to get a sense of the how the day in the life of a child with Conduct Disorder would go by. Through journey mapping, we were able to understand the daily routine of a child as he wakes up, gets ready to go to school, learns the various subjects from multiple teachers at school, and the way in which the time back home can be broken down.

Initially we tried to understand how any normal child would spend their day. We spoke to many mothers of children in primary school to get an idea as to how their day would go by. Also, we spoke with teachers to understand how classes are scheduled for primary school students. Based on this and the clinical case studies, we created a scenario with Rahul, our persona, who is showing the early signs of Conduct Disorder.

Through this scenario, we were able get an idea of the emotions Rahul would go through in a day. The valence was mapped accordingly. To this, objects Rahul interacts with on a regular basis were added along with a probable duration of the interaction. Based on these, the pain points were marked out. Insights and possible goals were written to give direction to the what was previously already decided to be an IoT based solution.

The Journey Map is attached separately in the folder.

Insights

There were five key pain points identified from the journey mapping. The broad domains were communication, channeling aggression, neglect, lack of skills and increasing empathy. These were the main points that needed to be tackled if we were to be able to help the child who was developing Conduct Disorder.

One that we noticed was that there were multiple triggers of negative emotions while at school fo Rahul. Another thing was that there were multiple points for him to vent out his frustrations as well. This, along with the lack of parental supervision, made for a compelling argument as to why we should deploy emotions sensing technologies to detect emotions of the child while in school.

A challenge that arose from this was whichever method we chose to deploy the technology, it had to be discrete. Children are very susceptible to social anxiety and a fancy device, which would undoubtedly do its duty in detecting emotions accurately, would however attract unnecessary attention and might make the child not want to wear the device again.

Tracking the emotions while at school also provided scope for parent-child bonding activities based on occurrences at school.

Keeping this in mind, we started to brainstorm for possible solutions that would allow for unobtrusive detection of the vitals that give us insights into the possible emotions a child is feeling.

Based on the the mapping of the objects the child interacts with, “Touch Points”, we noticed that the school clothes, ID Card, Pencil box, and school desk and chair were the objects the child was most likely to interact with during the course of a day. Amongst these five, all but the first one had a really high chance of another child’s data corrupting the child we are trying to detect for as children tend to share objects throughout the course of the day.

This left us with school clothes as the only other alternative that would allow for continuous and undisturbed monitoring of emotions. We shortlisted four items to be possible areas to attach emotions sensing technologies to - tie, belt, collar and shoes.

We decided to prototype to see what works best. And so, I went to the market to see what sensors were available.

Market Research

SP Road, in Bengaluru, is the place where you can buy anything and everything you need. From raw materials like metals to motors and laptops, you get everything. This place also has shops which deal with manufacturing sensors for large scale production and sensors for small pet projects.

I visited three shops, namely Vishal Electronics, NSK Electronics and Shree Electronics to figure what sensors are available and the various ways in which they can be used.

Shree Electronics

Vishal Electronics

The market research revealed that most of the sensors we hoped to use for our prototypes, weren't available and would have to be imported. This put our smooth sailing flight into a vertical stall.

We realised that of all the sensors we had initially marked out, only the force sensors, pulse sensor (optical sensor), Electromyogram and the Electrocardiogram were available. Of these, the EMG and ECG were too big to be practical and had a lot of restrictions on where they could be placed for optimum results.

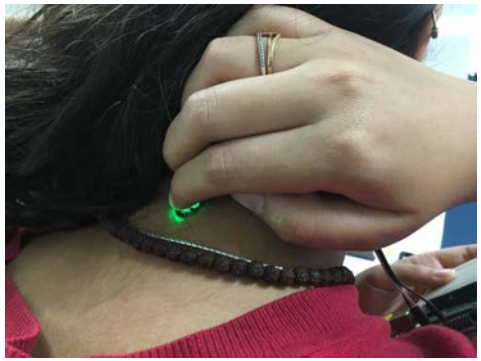
The pulse sensors and force sensors were bought for prototyping.

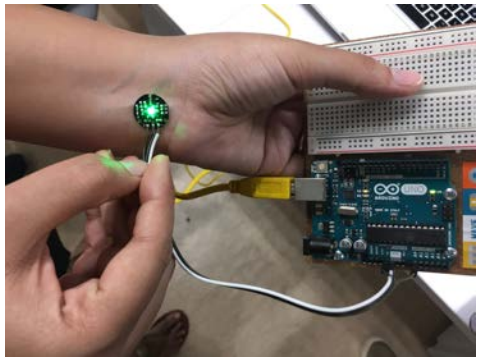
Prototyping

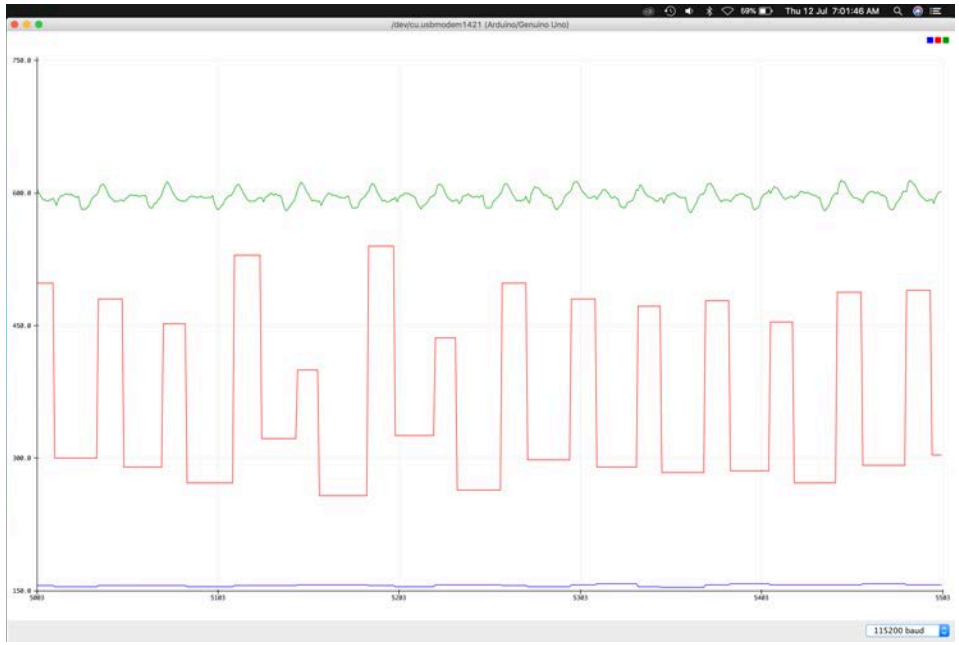
1. Arduino

We started prototyping with the pulse sensor, which gave a graph of the pulse, and the force sensor. The force sensor was highly inaccurate and required to be pressed in a certain manner. Also, the probability of the child getting frustrated and holding one particular item every time he/she gets angry was too low to consider further prototyping with the force sensor.

The pulse sensor on the other showed us promising results. The pulse was clear apart from a bit of external noise and after trying it out on multiple locations, behind the neck was where there was least disturbance through noise and hence, the location of the strongest measurable pulse. We also made paper prototypes to see where this would be comfortable and behind the neck, hidden away in a collar seemed to be right way to go.

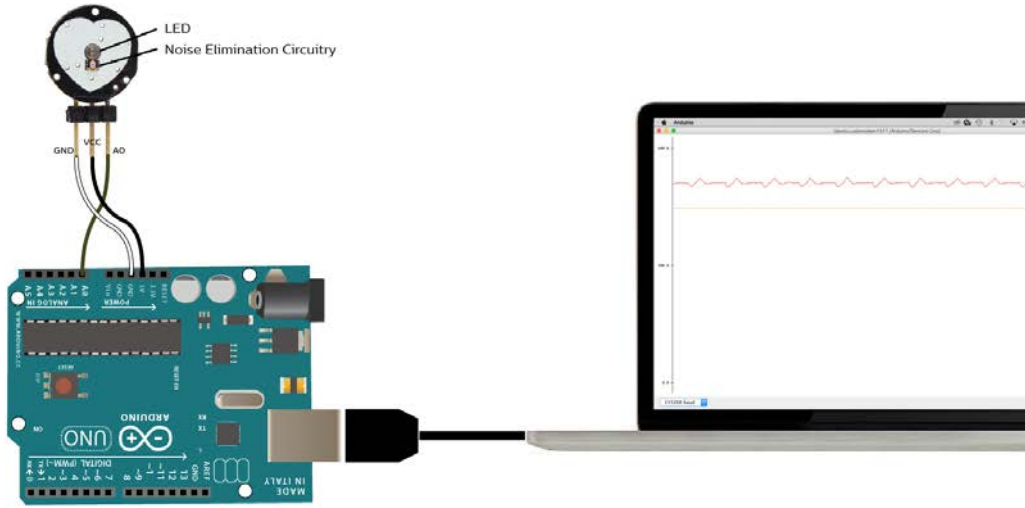






The pulse graph. The green line is the pulse.

Pulse Monitor Prototype



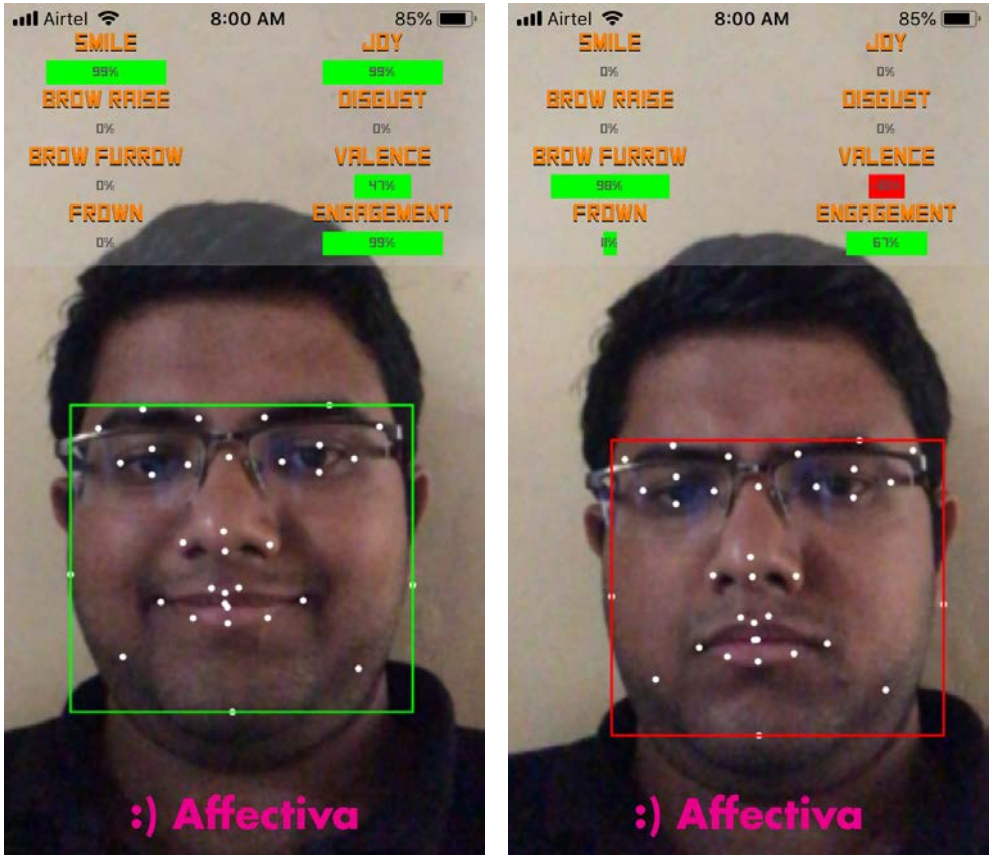
How the Arduino is connected.

2. Affectiva

The second part of the prototype was using the camera to detect facial muscles which we use to make expressions. These expressions, as described earlier, arise when we feel certain emotions. The facial Action Coding System (FACS) is what is used to decode the expressions made by the face.

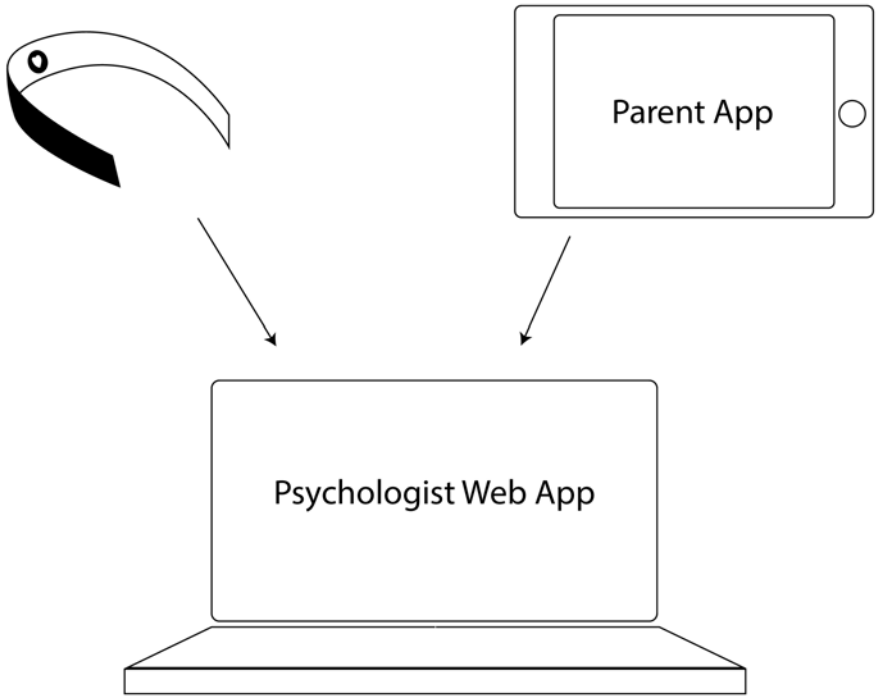
Affectiva is a startup from MIT Media Lab's Affective Computing division. Affective computing is the development of systems and devices that can recognise, interpret, process and stimulate human emotions. Affectiva has written scripts for various platforms which can utilise a camera to detect the emotions based on facial expression. This is what was tried for a tablet based application in one of our concepts.

The Affectiva SDK for Unity was used. But it was pretty challenging to figure out how the scripts were packaged. The test application was simple. To replicate a mouse click using any single emotion. This mouse click would cause the screen to flash once. But for reasons unknown, the SDK didn't have all the scripts necessary to execute this. The developer team at Philips too was unable to decode the scripts. But nonetheless, the application of the technology went into our final concept.



Final Concept

The final concept is a three part solution to help children with Conduct Disorder. It involves a collar which has a pulse sensor streaming data over the internet, a parent's app, and a psychologist's web application where the data streamed from both the collar and the parent app can be read and analysed.



1. Collar

The collar is attached to the school shirt via clips. It has a pulse sensor which is able to detect the pulse of the child from the back of the neck, as it is always in contact. This data from the pulse sensor is transmitted to the psychologist's web application along and is matched with other relevant data such as what class was going on at the particular time and who the child was interacting with (another student, teacher, with himself/herself).

2. Parent App

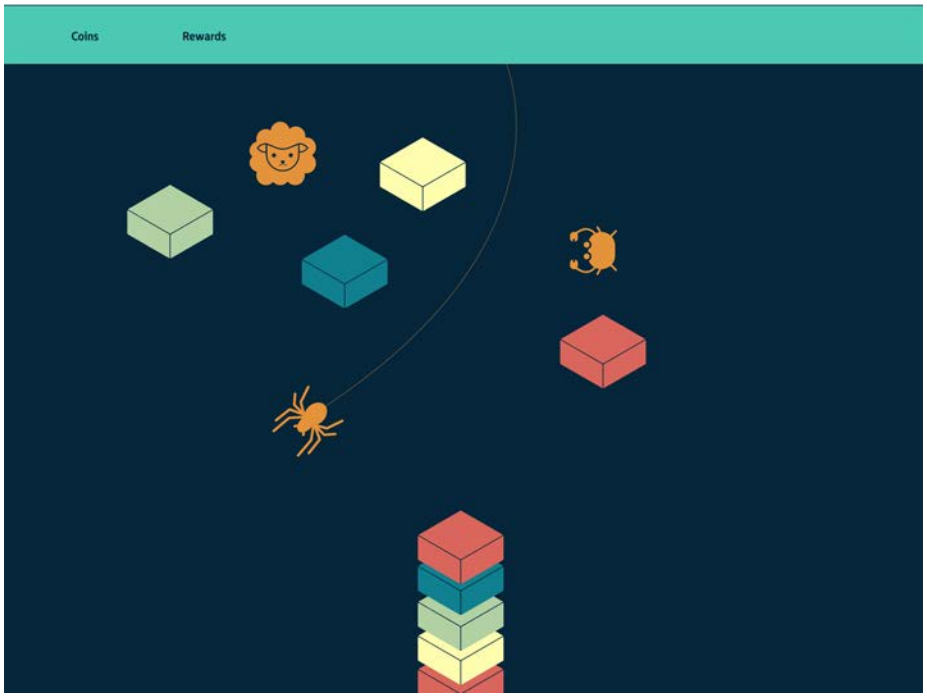
The Parent App is a game that is part of a psychotherapy session. The point of the game is to try to replicate triggers that the child would face in real life. Given that we are dealing with children with Conduct Disorder, one of the tendencies of these children is to destroy things as it brings them some kind of happiness. Putting another in pain and letting them suffer is one of the extreme traits of Conduct Disorder. The game basically tests their patience, self control and teaches compassion and empathy.

The technique used here is called reward therapy. The child loses points for getting distracted and gets rewards for exhibiting self control. Using Affectiva's emotion API, we can detect at which points the child gets distracted and the emotion he/she exhibits as a result of this. The

emotional reaction to this as well can be recorded to provide the psychologist a better foundation to work with. Affectiva uses a camera to track the emotions and so this App will be on a tablet.

The game is called Beat the Clock. The goal is to build a specific predefined pattern using blocks. While building, there will be distractions such as bees flying across the screen, or a frog hopping by. When the child sees this, he can choose to either continue building the pattern or he can let go of his/her block and squash the fly or boot the frog. Every time he/she decides to drop the block and take care of the distraction, a coin is lost. The game starts with 50 coins and ends when the count reaches zero. It is constantly manipulated by the emotions the child is showing, for example, reducing the number of distractions of the child is getting angry or putting a timer on the distraction so that the child knows how long he/she will have to wait before the distraction goes away. Based on this information, the child can choose whether to act or not on the distraction. Each time the child ignores the distraction and shows shows restraint on his/her part, he/she is rewarded.

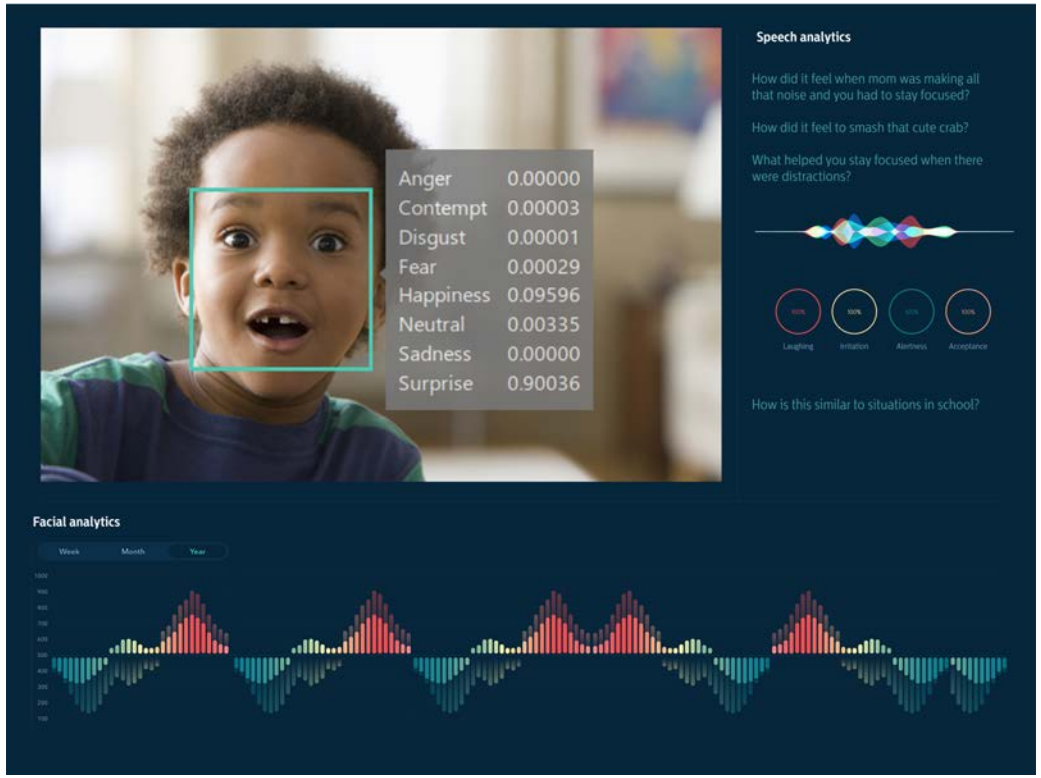
To the right, is a basic wireframe of how the game will look like. The blocks are supposed to be stacked one on top of the other in this game. The crab and spider are distractions that the child can choose to act on. He/she can, for example, either squish the insects or block them with the blocks. The sheep badge in this case is the reward the child can collect at anytime. This reaction is recorded and the emotions are sent to be analysed by the psychologist on their web application.



3. Psychologist's Web Application

This web app is an analytics tool. It displays information about the child's emotions during the week. A basic summary with the peaks which can be expanded for a detailed view. The psychologist also gets a video stream of the child playing the game and the emotion stream as detected by Affectiva.

Based on this information, the psychologist can guide the one in one sessions with the child.



Learnings

Emotion Sensing is a new area with a lot of potential. The multitude of possibilities using very simple and inexpensive sensors is overwhelming. Having said that, I do not think I was able to explore the potential of this technology while at Philips. Personally, I feel the technology has a better use case for things like patient monitoring, helping autistic children and senior citizen care. I felt disconnected to the problem at hand and found it hard to stay focussed.

But more importantly, working with other interns and employees at Philips has stressed upon me the importance of prototyping. Prototype fast, fail fast, and know what the technology is capable of. Emotion sensing was a new area to me and the promises it offered initially and what we were able to finally do came as a quite shock to me.

I also realised the how much of a difference the ability to meet users makes to a project. Most of the project was based on assumptions. The only kind of verification we talking to mothers at Philips about how their children's day goes by and the Conduct Disorder part of the story through talking with a doctor. It also made me understand the realities of designing in the healthcare space. Most of the time, there is no direct interaction with the patients themselves as they would be under a lot of stress and going through trauma as a result of their own treatment. I was told that it doesn't make sense to talk to patients in this condition as it is outright unethical.

The project, being part of the Innovation Program at Philips, is an ongoing operation. The next stage would be to actually integrate the pulse sensor into the collar on the physical prototyping side. As for the software prototype, the game will have to be further refined and defined before it can be prototyped with Affectiva.

Emotion Sensing opened up new avenues and I'd love explore this area further.

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