Virtual situated display in hospital ward

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ABSTRACT
In this paper we describe the concept, development, reflection and conclusion of the second mandatory assignment of Pervasive Computing course (Spring 2015) at IT University of Copenhagen. The project describes the construction of a wearable system that tracks hand gestures to interact with a mobile Augmented Reality environment of X-rays pictures that allows medical doctors to interact with a touch-less interface that is able to browse through electronic health records. The physical goals of the system were the devise to be as small as possible built with an Arduino Mini and an IMU sensor. The computational goals of the system was to build an application that is able to track and recognize particular hand movements in real time in order to control the presented medical images.

Author Keywords
Ubiquitous and mobile computing, HCI, Augmented Reality, Arduino, Wearable Computing, Electronic Patient Records, Bluetooth, X-rays, Google Glass, Arduino Mini, BayesNet, WebSocket, Weka

INTRODUCTION
As time goes the technology grows exponentially, every day new technological paradigms emerge, developed and investigated. Now days there's a high acceptance of multimedia, Internet and desktop computer as daily concepts among us and one of the most important goals in the area of technology has always been to try to find the best way for man and machine to interact with each other, that means, how can get we the best use from the machine and how the machine can help us to perform such activity. [HCI] Each invention or research done in the field of technology heads to make our life easier, by providing solutions and answers to problems that are emerging as the technology increases as well.

With the explosion of mobile computing it's becoming inconvenient to operate with standard human computer interfaces. As people are walking or working in daily routine, holding or manipulating a traditional electronic gadget it's becoming increasingly impractical. [5] The result of this inconvenience results in the recent and big innovation of Wearable Computing.

The Wearable Computing offers an exceptional condition of ubiquity and integration with the environment, communication and data analysis which in turn is more and more appealing for companies and users to invest in this new paradigm, this is the reason why wearable computers establishes a much closer interaction between technology and the user and why wearable computers allow a much closer association with the user [1].

Without a doubt, wearable technology is a commented topic currently and in the recent years, it stands to reason that it will become integrated into society as useful mean in everyday life.

MOTIVATION
With the system we are presenting, medical doctors have the opportunity to have instant access and control of Electronic Patient Records of each patient with a touchless interface.

This project was an inspiration to explore with some technologies such the Arduino, IMU sensor or Bluetooth, and in order to finish it we went though the construction of a device for sensing input, the handling and usage of Augmented Reality, and the development of the program for gesture recognition involving Weka application.

The exploration of a wearable system opens the doors to interaction in the same level of the natural activities we normally do such a gesture with computational systems that takes advantage of that activities making them very useful activities.

By maintaining a community of users exploring and researching wearable devices, we hope to explore and encourage a diversity of different applications and styles in the field.

CONCEPTUAL DESCRIPTION
Each patient has a tag that is allocated for him. When the doctor wants to see his record, he must use some device such as Google Glasses or Mobile phone. When the doctor pairs the camera of the device with the tag of a certain patient, the X-ray of the patient appears on the screen in an Augmented Reality interface as is shown in figure 1.

The user wears the device on the wrist detecting movements and sending data from it thought Bluetooth to the application that interprets the collected data and gives the opportunity to interact with the X-rays pictures with simple hand gestures.

SYSTEM ARCHITECTURE
To document the architecture of the system, we will split it into a number of tasks:

- Augmented Reality-based user interface
- Building the wearable IMU sensor
- Input, sampling and pre-processing the data
- Hand gesture recognition

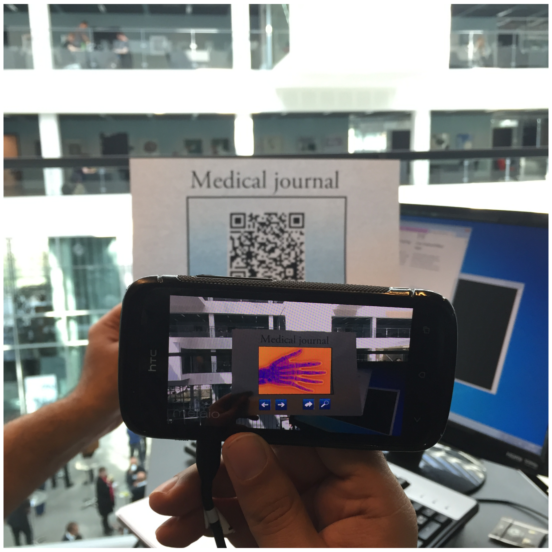

Figure 1. Augmented Reality interface

Figure 2. Tag before and after the segmentation

AUGMENTED REALITY-BASED USER INTERFACE

Augmented reality integrates real-world signals captured with computer signals to make them coexist and create an enriched world. This technology uses the technologies of the visualisation to build applications and contents with qualities and gives the opportunity of interaction. [7]

The human visual system, and the other sensors perceives the physical or real world within a context. This perception is a reconstruction of an interpretation, the reality is multidimensional and multicontextual.
Augmented Reality allows to break down the different aspects of that interpretation in order for the human visual system to receive and re-interpret them in the same new reality.

The system we are presenting starts with the record of real-word signals that are processed by a Augmented Reality System that enhancement the edges of objects in the record to prepare the image to segment or to extract and a pattern recognition of the tag, which is shown in figure 2. [7]

When the system detects this tag the interface extracts it and implement the X-rays images in it place the screen display , ready for their interaction.

This interaction of the images presented in the Augmented Reality is through the data send from the wristband, we will describe in detail in the following sections.

BUILDING THE WEARABLE IMU SENSOR

In the last section we did a review of how the application is going to be ready for the interaction in the Augmented Reality, to achieve this interaction the system is receiving the information of hand movements from a wearable IMU sensor made with this sensor, an Arduino Mini, Bluetooth device and other components.

As a opposed to traditionsl PC Arduino features capabilities that are able sense and detect signals from the physical world. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.[9] As we mention before, the Arduino is connected to an IMU sensor that is an inertial measurement unit which is a electronic device that measures and reports a craft's velocity, orientation, and gravitational forces, using a combination of accelerometers and gyroscopes.[8]

There are a variety of Arduino boards. One of the goals of the project was to make it wearable and as small as possible, which is the reason for using the Arduino Mini board.

Arduino Mini is a small microcontroller board intended for use on breadboards and when space is at a premium. It has 14 digital input/output pins, 8 analog inputs, and a 16 MHz crystal oscillator.[10]

In order to configure the board and also the bluetooth, we add the library FreeSixIMU to the board of Arduino, add a power switch and a battery in order to be wireless. The final connected product is shown in figure 4.

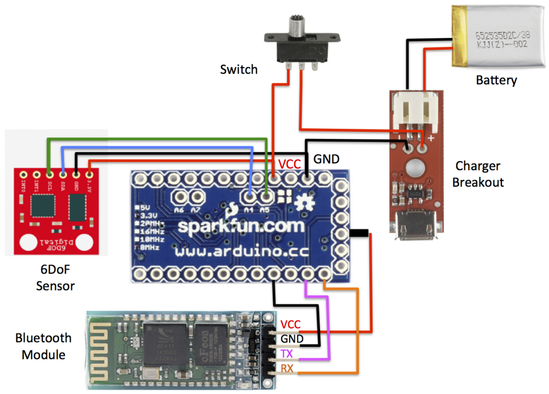

Figure 3. Wristband connections

INPUT, SAMPLING AND PRE-PROCESSING THE DATA

To receive data through a Bluetooth connection from the Arduino wristband we just built to the device (Google Glass, mobile phone, etc.) it is necessary to create a recorder application in Java in order to get the acceleration and rotation data of the sensor. This application reads the data through the serial port.

The data samples that system recorded are from the acceleration and rotation which captures six axis data (AccX, AccY, AccZ, GyrX, GyrY and GyrZ) from 6 gestures: up, down, left, right, rotate left, rotate right and idle as is shown in figure 5. This information is stored in a .csv file to be pre-processed afterwords. We recorded around 24 samples of each gesture and in order to pre-process it, it was necessary to clean it and leave the same amount of cleaned samples for each gesture. We decided to use 19 samples, deleting the first and the last ones reduce risk of using error prone gestures that where captured in the beginning and the end of the recording. The first 10 were used as a training set and the last nine were used a test set to cross validate against the training set.

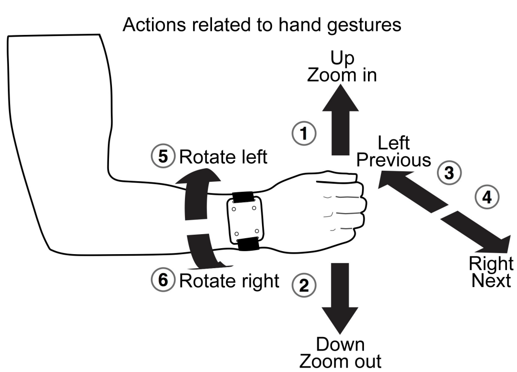

Figure 4. Hand-gestures

HAND GESTURE RECOGNITION

Hand gesture recognition is becoming a more common interaction tool in the fields of ubiquitous and wearable computing. It has gained a lot of attention due to benefits of using it in applications with interactive human-machine interface and virtual environments [12]. Using gestures as a way of communicating with an interface in a virtual environment is naturally the way to go.

In order to recognize the hand gestures by analyzing the acceleration and rotation data from the wearable sensor, we collected the training data we described in the previous section and tried different classifiers that recognize patterns which help to differenciate between gestures. To do this, we used Weka, that also supply a collection of machine learning algorithms for data mining task, it contains tools for data pre-processing, classification, regression, clustering, association rules, and visualization. [14]

We compared the performance and accuracy of different classifiers: J48, BFTree, NaiveBayes and BayesNet. We chose to use BayesNet since This classifier was the one that performed better for our data. The results of the analysis are shown in the figure 6.

Once we applied bayesnet on the dataset and build our classifiers, we were able to call an instance of it as classification model. This would be used to detected gestures from the live data that was captured. Subsequent we would create instances from the live data by using the concept of sliding windows which means, in our case, we created instances from every 180 samples of readings and jumping a certain amount sample forward, 60 in our case. Each instance would then be compared by running it against the classification model. The model would finally return a double value to indicate which gesture was the likely one that was made.

```
=== Evaluation on training set ===
=== Summary ===

Correctly Classified Instances          70               100      %
Incorrectly Classified Instances         0                 0      %
Kappa statistic                          1
Mean absolute error                      0
Root mean squared error                  0
Relative absolute error                  0      %
Root relative squared error              0      %
Total Number of Instances               70

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
                 1         0          1          1         1          1        up
                 1         0          1          1         1          1        down
                 1         0          1          1         1          1        left
                 1         0          1          1         1          1        right
                 1         0          1          1         1          1        rotate_left
                 1         0          1          1         1          1        rotate_right
                 1         0          1          1         1          1        idle
Weighted Avg.    1         0          1          1         1          1

=== Confusion Matrix ===

  a  b  c  d  e  f  g   <-- classified as
 10  0  0  0  0  0  0 |  a = up
  0 10  0  0  0  0  0 |  b = down
  0  0 10  0  0  0  0 |  c = left
  0  0  0 10  0  0  0 |  d = right
  0  0  0  0 10  0  0 |  e = rotate_left
  0  0  0  0  0 10  0 |  f = rotate_right
  0  0  0  0  0  0 10 |  g = idle
```

Figure 5. BayesNet Evaluation

The flow of the system starts by opening the listener for the WebSocket, WebSocket is a protocol providing full-duplex communication channels over a single TCP connection and it's where the communication with Junaio or Metaio where the program is made through.

When the program establish connection with Junaio or Metaio, the reader for gestures starts, does the comparison of the input with the model and starts the interaction. The concept visualisation of the Java program is shown in figure 6.

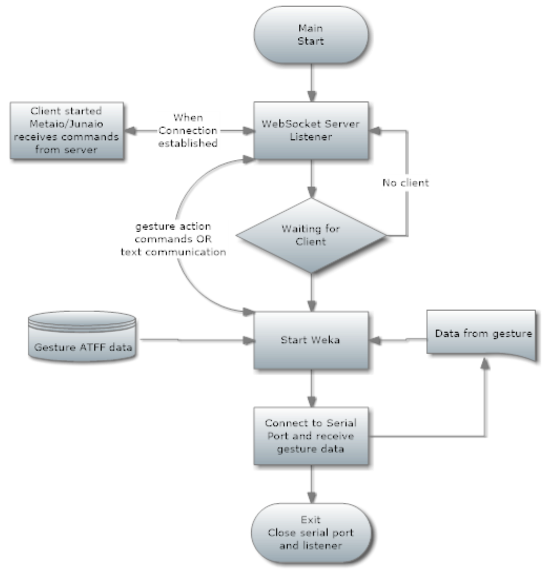

Figure 6. Flow of the system in the code

CONCLUSION

Wearable computing give us the opportunity to explore augmented realities becoming more and more a digital assistant.

The ability of augmented reality to incorporate real objects with virtual objects in the same stage, allows the use of real devices to manipulate virtual objects and its actions or behaviors. There's a lot of work to develop in this technology but the hard work in the area during the last years has mounted to useful applications in education, health and entertainment. Augmented reality is ready, more curious users are missing for exploring the technology to impulse developers to take it to the next level.

The result is a rich combination of physical and virtual realities that can intelligently assist the user in a very useful way reaching one of the goals of HCI.

REFLECTION

In the result, the system was able to recognize not more than 3 gestures, if we wanted to add more the system would lose so much accuracy. The problem was specially with opposite gestures because the data is similar: right-left, up-down, rotate left-rotate right.

The development of the system was very interesting for the understanding of the concepts involved and the system in general. We think it's very useful application, nonetheless it's not a new idea as a product, since the year of 2012 exist similar projects involving the same utilities. [6]

The use of Augmented Reality is an innovative technique to explore and very suitable for the system, specially for security issues of the records shown in the pictures. Another really good opportunity to implant the project could be with parts of the body in 3D where you we can reach more of the field of Augmented Reality, specially for medical doctors doing surgery.

There's a wide open options of opportunities very good economical retrieved in the fields we covered by the system. According to Gartner, apps and services for health may generate up to 5 billion dollars by 2016, These devices wont just be for consumers, but also healthcare systems and businesses that want to monitor activity and provide incentives for employees healthful living according to a recent Forrester study called The Enterprise Wearables Journey. [2]

We hope to keep working with similar projects specially to increase the knowledge of getting better accuracy of the gestures, in general, the project was a mine of knowledge for the group.

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