ESE 519 Final Project

A REAL-TIME HOUSEHOLD INFOTAINMENT SYSTEM

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Abstract

Our project included the development of a real time home infotainment system. The main objective of pursuing this project was to understand the challenges faced in the domain of Internet of Things and adapt the theory to a Home Infotainment system. The Infotainment system, that we developed during the course of this project consists of an environmental sensing subsystem, a health monitoring unit, a gaming module and an art module. These modules were supplemented by actuation and control sub-systems.

Introduction

The Internet-of-Things (IoT) connects devices such as everyday consumer objects and industrial equipment onto the network, enabling information gathering and management of these devices via software to increase efficiency, enable new services, or achieve other health, safety, or environmental benefits [1]. The everyday objects can be smart phones, Internet enabled TVs, sensors and actuators to the Internet where the devices are intelligently linked together enabling new forms of communication between things and people, and among things themselves as well. As IoT grows more prevalent in our society, it's application in creating new concept and wide development space for smart homes to provide intelligence, comfort and to improve the quality of life provides a promising place for its implementation [2]. In this project, we develop real-time infotainment system integrated with environmental monitoring, health monitoring and an entertainment system.

Components and Methodology

An authenticated online accessible user interface for real-time monitoring, updates and actuation are provided. A smart glove is used for health monitoring sensors as well as to act as the controlling input to the gaming and the art drawing subsystems, is included in the final design.

Sensor Modules

Environment Monitoring and Actuation

The environmental monitoring and actuation module includes sensors like light intensity, temperature, and humidity for monitoring purpose and fan and light (in form of LEDs) for actuation purposes. The data obtained from the sensors is periodically updated to the cloud and the user will be able to access the information through the GUI on Raspberry Pi and the web application. Since the actuation feature is also the part of this module, the user can control the parameters like fan speed and light intensity by just dragging the slider on the web application. This mode of interaction between a user with his or her home objects provides real-time awareness and control which makes the experience richer.

Gesture Orientation Control

The gesture orientation control module houses an Inertial Measurement Unit (IMU), four flex sensors, mBed and a RF module on the gesture glove which users to perform gestures to control different modules of the system. Using the accelerometer and magnetometer data (roll, pitch and yaw) obtained through this module, user's hand orientation can be determined by calculating unit vector in direction of user's direction multiplied by a constant length. This information serves as an input that goes into controlling the gaming and the art drawing system.

Health Monitoring

The health monitoring module includes a pulse sensor which primarily measures heart rate of the user. The pulse sensor is attached to the circuitry components of glove for measurement easiness. This module continuously measures the heart rate of the user and sends the information to the environmental monitoring module which aggregates all the information required for displaying on the GUI by sending it to the central Raspberry Pi node.

As mentioned above these modules communicate the sensed data to a server on the cloud and the user will be able to monitor his or her physical health via web application and the LCD. Each of the above mentioned modules communicate with the central network node via Zigbee.

Central Network Node

The Raspberry Pi-based central node accumulates all the information obtained from the Wireless Sensor Network (WSN) and pushes the data onto the cloud where it becomes accessible to the user remotely. Furthermore, if the user wishes to provide actuation signals to appliances remotely, this node plays the responsibility of the central decimator. The network node will also be responsible for controlling the display and communicating with the gesture glove.

User Interface (UI)

Since monitoring is one of the goals of the system, we provide a suitable method to display this information. The LCD monitor is used and acts as a local display for the home network. The information provided by the above mentioned sensing modules are displayed on it. This same monitor also serves as the display for the gaming environment.

Web Application

The web application, developed using Ruby on Rails, provides a user remote access to his or her system. This application has user authentication feature. Once a user logs into his or her account, he or she will be provided with the same information that is displayed on the Local Monitor. Furthermore, the online control panel also allows the user to control the actuators remotely based on the information obtained from the parameters.

Gaming and Art Module

In order to showcase the entertainment capabilities of the system, a shooting game run on Raspberry Pi is developed in Python. The game is displayed on to the local monitor and controlled through gestures

sensed by smart glove. The functionality of the art module is to allow real-time drawing on the LCD display. The IMU is used to capture the glove's roll, pitch and yaw, and the vector of orientation is calculated to determine the coordinate on the drawing canvas. These values are filtered using a moving average filter to eliminate noise. The act of draw is executed whenever user holds his/her forefinger (firing angle decided on the basis of a threshold set for the flex sensor on the forefinger), and drawing color can be changed through ring finger.

Testing and Evaluation

Architecture for information flow of the home infotainment system can be seen as below.

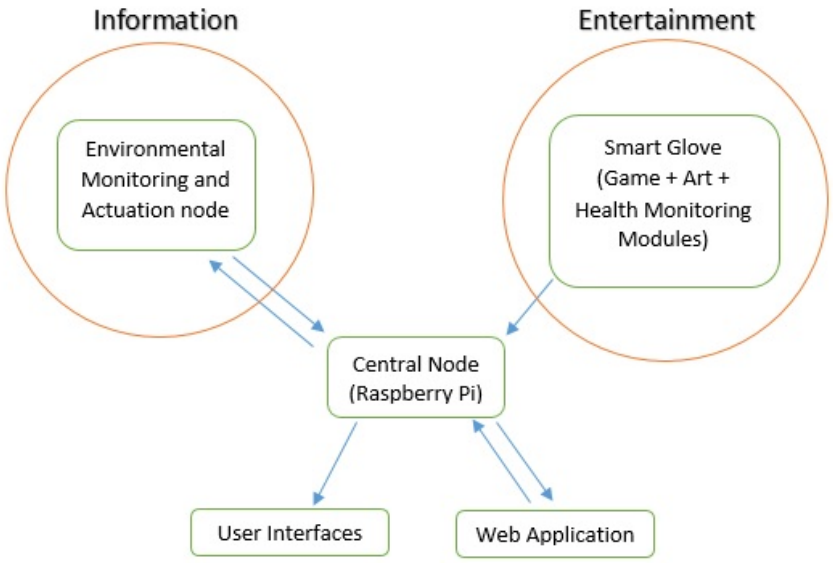

Fig 1. Home Infotainment System Architecture (*Direction of arrows represents one/two way flow of information)

Snapshots of different modules :

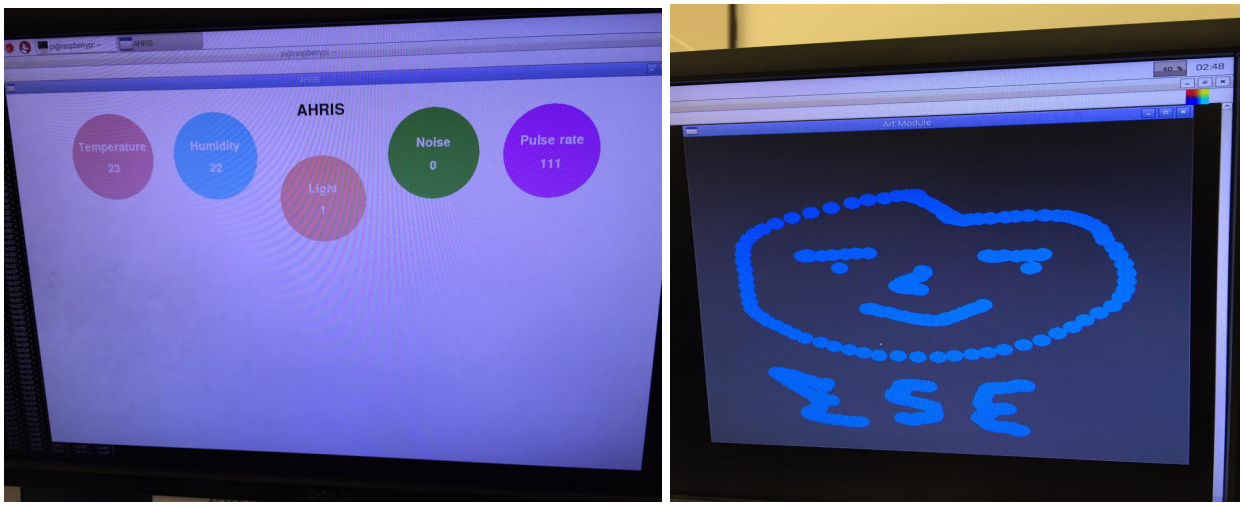

Fig 2. Information and Art Module GUI

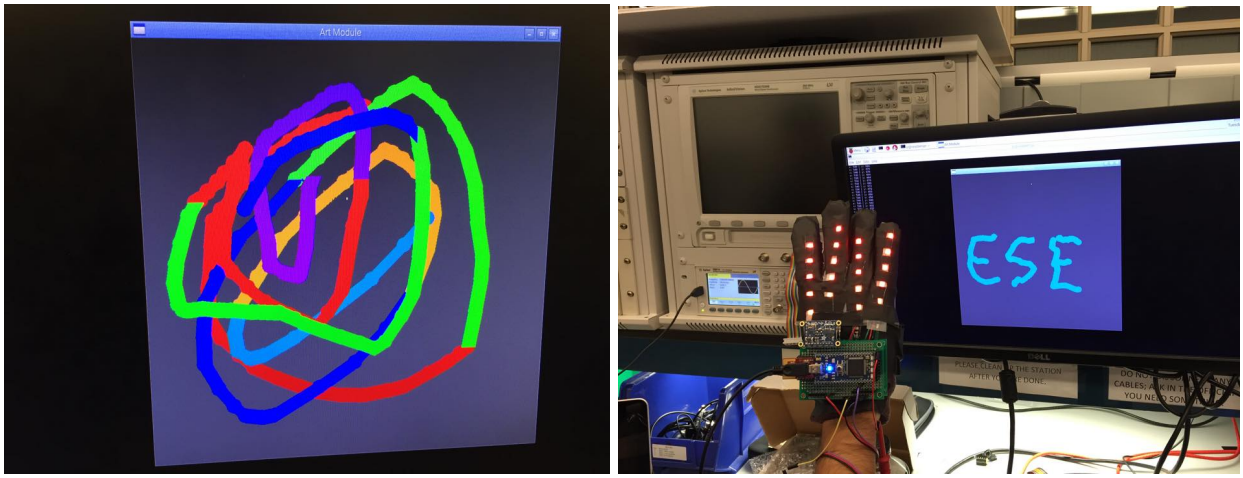

Fig 3. Drawing sample from Art module and Smart Glove

Conclusions and Future work

The project goals have been met, and a working prototype has been introduced to demonstrate the work. The central node along with the sensor nodes and two actuators, web application, Raspberry Pi for the gaming and drawing canvas and the smart glove are working to their specifications. Future work would be to integrate the individual sensor nodes and circuit on the glove into PCB boards for size improvement. More games could be added into the gaming module, and the drawing canvas could be improved with more imus deployer along the arm. Separate modules on Raspberry Pi could be integrated into a single one. Different modalities of interaction like voice control, emotion control by Brain-Computer Interface (BCI), etc along with more advanced gesture control can be introduced. Also, the data collected from sensor nodes can be aggregated and processed for connected intelligence applications.

References

[1] http://www.goldmansachs.com/our-thinking/outlook/internet-of-things/iot-report.pdf

[2] Kortuem, G.., Kawsar, F., Fitton., D., Sundramoorthy, V.: Smart objects as building blocks for the Internet-of-Things, Internet Computing, vol. 14, no. 1, 44 - 51 (2010)

Team Member's Individual Contributions

Aditya Deshpande

- Building web application
- Designing environmental monitoring node
- Gesture control glove design
- Designing GUI on python for displaying gaming application and information collected from sensors
- Integration of system as a whole
- Making and maintaining the blog

Nishank R Shinde

- Designing GUI on python for art module
- Extracting heart rate data from the pulse sensor (health monitoring node)
- 3D printing supporting base plates for housing PCBs of different modules
- Integration of system as a whole
- Gesture control glove design

Cheng Cheng

- Gesture control glove design
- Integration of system as a whole
- Extracting heart rate data from the pulse sensor (health monitoring node)
- Blog video editing and sharing