**Memo**

To: Professor Alan Pisano, Professor Osama Alshaykh, Fulya Ekiz Kanik

From: Caroline Jones, Michael Haley, Sneha Pradhan, Tanatsigwa Hungwe, Zehua Zhao

Team: 1

Date: 04/26/17

Subject: **Customer Installation Report**

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1. **Customer Installation**
   1. Details

The Luminesense system was presented to the clients Professor Thomas D.C. Little and

Dr. Michael Rahaim on April 26, 2017, at 2:30 pm. The team members present for this

installation were Caroline Jones, Michael Haley, Sneha Pradhan, Tanatsigwa Hungwe,

and Zehua Zhao. The product was installed into the Smart Lighting Undergraduate

Research Program (SLURP) Laboratory, Room 208, in the Photonics Building, located at

8 St. Mary’s Street.

1. **Requirements**
   1. Requirements Assessment

Upon commencement of project development, the customers requested numerous requirements. Amongst the requirements, most were satisfied and if not, were tweaked a little. The following are both the initial, and finalized requirements:

* **Gesture language**: due to IMU limitations, a large set of gesture commands could not be built and made available to the user. However, the smaller set of gestures will be used to cycle between different commands to extend the depth of the language. This language will be used to effectively interact with the system. An accompanying dictionary that describes and explains all possible gestures will be provided.
* **Wearable transceiver**: this body-worn device communicates with the system components (the Raspberry Pi and the luminaires).
* **Control software**: Several algorithms were designed to accomplish several tasks. These tasks included recognizing the mode of engagement (adaptive or gesture), the information sent to/received from the wearable, the Raspberry Pi, and the Photons. Additionally the software controlled the states of the luminaires, the adaptive procedure of the system, and the management of the database.
* **Web application**: An interactive interface which allows users to store their lighting preferences on the cloud (via Heroku). Additionally, this requirement was extended to include remote interaction with the system via the web app.
* **Web server**: A web-based solution to monitor, document and report the system's performance over time (energy savings and functionality test results).
* **Video**: A demonstrative video exhibiting the product's features and functionality. This video will include operation of the system within the client's’ laboratory.
* **Report**: A document (together with a GitHub repository) which details all research, problem-solving methodologies, design choices and considerations made in the span of the project's lifecycle.

1. **Future Plans**
   1. Overall

Going forward, the team plans to expand upon the features already present in the system. This includes creating a more robust and configurable gesture library via extending the depth of the gesture language, redefining the separation between the adaptive and gesture modes, adding versatility to the gesture commands, and simplifying the luminaire selection procedure. Finally, the project would be documented and developed in order to prepare future engineers to resume development on the system. These considerations were discussed with the clients in great detail.

* 1. Gesture Library

Currently, Luminesense supports four gestures. These gestures are detected by analyzing the accelerometer and gyroscope data from the Arduino 101 to determined the orientation of the board. The gestures implemented takes advantage of the axes of rotation of the board’s edges. This is extremely limiting, as this implies that only four gestures are created. Future work would include implementing a machine learning library in order to allow more precise gesture commands, as well as to give the user more freedom in configuring their own gestures, in which they can make up their own as opposed to selected from a predefined pool of recognizable gestures.

* 1. Adaptive Mode Sensing

One problem that came up during installation was interference between the adaptive mode and gesture mode. For example, the adaptive mode would sometimes interrupt a user when the user was trying to select luminaires to interact with. For the purpose of the client demo, a mere 10 second time-out was set to turn the lights off after this period of inactivity. This wait time will be considerably increased to prevent any form of user disruption going forward (upwards of 15-30 minutes). Fine tuning this protocol’s sample rate would remedy this issue. Other considerations include implementing a system-wide state machine in order to control the system being in the gesture state or the adaptive state.

* 1. Luminaire Selection

The issue with luminaire selection is closely related to our rudimentary gesture library. Because we had only 4 possible gestures, a button based solution was created for luminaire selection as opposed to a gesture based solution. Current plans are to add depth to the gestures already present. For example: rotate clockwise signifies “red”. A repetition would result in “blue”. Another would include “green” and so on. This method of cycling through commands would add depth to the gesture library. However, for future engineers, it would be ideal to control selection through gestures. This idea is more intuitive and is in line with the gesture-based schema behind the entire system.

* 1. Website Improvement

Currently, the website is configured specifically for the system that we have installed for the client. In the future, we would like to support multiple users on the website in order to support more than one luminesense system. This would include letting users register and keeping track of their own preferences and data.

* 1. Selection Mode Indicator

Currently, the system does not provide feedback to the user on which luminaires have been selected during the selection phase. The client has requested that we provide a visual indication that a luminaire has been successfully selected. The client suggested that the luminaire change color or blink to indicate that it has been selected. We will be working to try to implement this before ECE day, and update our client once it has been completed.

1. **Client Response**
   1. Overall

The product installation procedure involved performing ideal user scenarios: engaging in the gesture and adaptive modes. In gesture mode, the user would turn on the wearable device, activate the session, point to and select luminaires, perform gestures, and subsequently end the session. In adaptive mode, the user would leave the system environment for a brief moment (~15 seconds). Consequently, the luminaires would shut off. The user would then re-enter the environment, reactivating the luminaires. This procedure was exactly the same as the functional testing performed on March 31st, 2017. This procedure examined wearable functionality, luminaire selection, gesture performance, database management, and web application utilization. Overall the system was well received by the client as it met all of the major requirements outlined at the beginning of the project. Incidentally, the design’s modularity facilitates future iterations of development on the system. The clients gave advice and made technical comments regarding the final system design. Additionally, they suggested ways to visually exhibit the product’s features and functionality.

* 1. Email/Letter

Professor Little was unavailable to pen an acceptance letter; however, during the installation procedure, he expressed his satisfaction with the alpha product. Additionally, he reached out to many of his colleagues - Professor Alan Pisano and Professor Alshaykh - and expresses his satisfaction with Team 1’s progress and was optimistic about continuing the project for the summer and fall terms. He subsequently commissioned an expansion on the number of luminaires in the lab - indicating his desire to increase the scope of the project. Dr Rahaim shared the same sentiments during the installation procedure. He hopes the product can be integrated seamlessly into his own VLC research project. Additionally, he expresses his satisfaction with Team 1’s progress and and was optimistic about continuing the project for future terms.