IoT Health : Sensor Monitoring System

Angel Castro[2]
Sharad Mehrotra[1], Roberto Yus[1]
NSF REU IoT-SITY Summer Research Program
[1]*Donald Bren School of Information & Computer Sciences, University of California, Irvine*
[2]*University of California, Santa Barbara*

INTRODUCTION

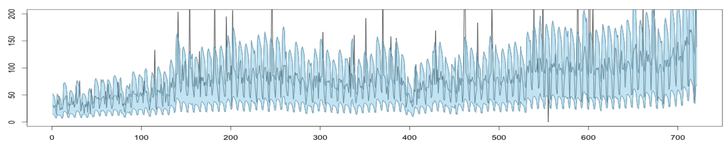
The research project is a part of Testbed for IoT-based Privacy Preserving Pervasive Spaces (TIPPERS), a smart building system at University of California, Irvine (UCI) that focuses on preserving privacy. The ultimate goal is to create a space that allows users to control privacy options while providing a variety of services. The research project involves creating a system that will monitor the health *(status)* of the sensors used throughout the building. This elicits reviewing the state of the art in the sensor anomaly detection field and tailoring existing algorithms to the different sensors in TIPPERS. This project will explore how to best modify existing algorithms for the variety of sensors. Through the incorporation of anomaly detection, the entire smart building will become more resilient and dependable. This research can be extrapolated to many Internet of Things environments where it is necessary to have functional and accurate devices at all times.

- **Identify** faulty sensors
- **Monitor** Health overtime of all sensors
- **Notify** management of sensor health problems

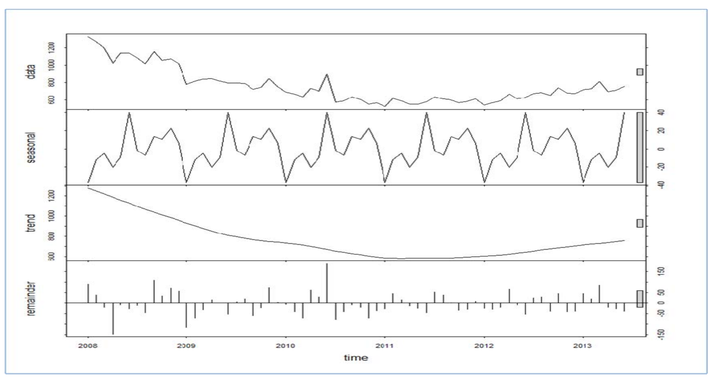
METHODS

Anomaly Detection Methods

- Median Absolute Deviation Method
  - a statistical technique that calculates a score for each incoming data point. It uses a sliding window of data points for which it calculates the median and the median absolute deviation. First, a score is calculated for each data point using the MAD method. Once a score is calculated, a sensitivity is set to determine which points are anomalous.



- Extreme Studentized Deviate test
  - Decomposes the incoming data into three components. The first is the trend line, this shows the overall change in the data. The second is the seasonal component, this shows the periodic data that appears in the data which can arise from differences in day and night, weekday and weekend, and other periodic causes. Lastly the residual component, this is the component that is left after removing the trend and seasonal component from the original data. It is from this component that anomalous data can be detected. This method is very useful because anomalies can be hidden between the seasonal and trend components. Therefore, this method allows for improved anomaly detection. The MAD method will be used for temporal analysis while the ESD test will be used for long term analysis of the data.



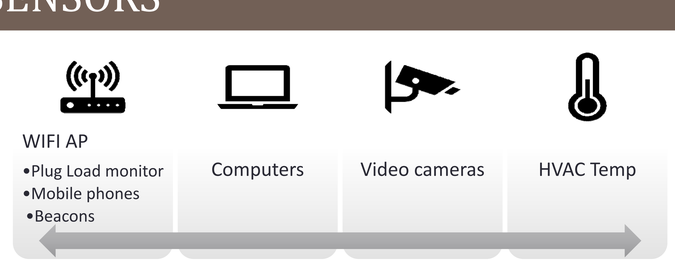
TIPPERS

Donald Bren Hall in UCI

TIPPERS is a smart building system at University of California, Irvine. The research system is currently implemented in Donald Bren Hall which is a six story building on campus that houses classrooms, offices, and labs. It is comprised of several different sensors throughout the building that gather data on users and users' preferences. The primary focus of TIPPERS is to use these sensors to provide services but also maintain and allow privacy options for users. IoT environments collect a continuous amount of data with little consideration of privacy. The data is allowed to be analyzed and determine things about the users such as location and preferences. TIPPERS focuses on still providing access to such data while ensuring that only the information that the user predetermines to be used is utilized.

The potential services that TIPPERS can provide are emergency evacuation tally in order to ensure that everyone is safely out of the building, attendance keeping to make sure that students, and faculty are showing up on time, detection of suspicious activity for security purposes, and room temperature preferences that adjust to the adjusted preferences of everyone in the room. TIPPERS is meant to be a versatile system that can continue to expand and facilitate more services and sensors. Other services include in-building navigation to meet with someone and smart conference meetings.

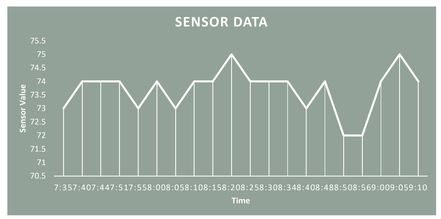
SENSORS

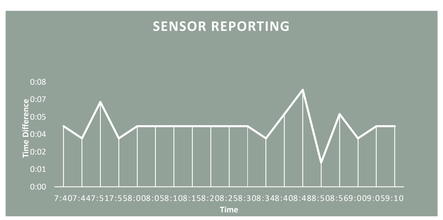


APPLICATIONS

The methods described will be applied in two different ways to ensure functionality of the sensors. The first application is to use the methods to detect anomalies in the data observations made by the sensors. This will allow us to determine whether there is an environmental anomaly or the sensor is collecting faulty data

The second application is to use the techniques described to detect anomalies in the reporting of the sensors. Several of the sensors can be expected to report observations with some periodicity. This property can be used to determine if a sensor is reporting as expected. Detection of these kinds of anomalies can help identify faults due to network issues, sensor connection, sensor reporting components. The approach that will be taken for this application is to analyze the time difference between consecutive observation. Then run anomaly detection methods on the time difference of each observation.



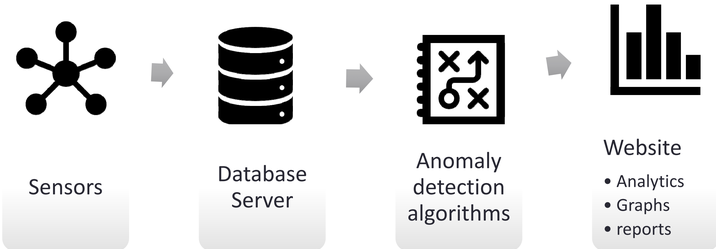


PROBLEM STATEMENT

Devices in IoT environments are susceptible to malfunctions and outside factors that will affect their performance. IoT environments depend on the devices in the network to remain functional and reliable to accomplish a goal or provide a service such as in the case of TIPPERS. Therefore, it is imperative to be able to detect when an error occurs so that action can be taken to correct it and the system can be resilient to such errors.

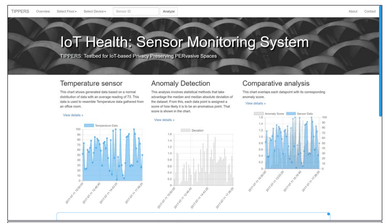
- Powered off
- Dead battery
- Disconnected
- Network issues
- Environmental issues
- uncalibrated

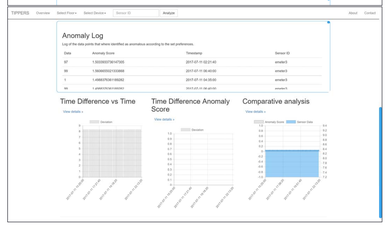
DESIGN



IMPLEMENTATION

The website allows for analysis of the devices throughout the building. Analysis can be done for the different types of sensors, the floor of the building, or on specific sensors. The data is requested from the TIPPERS API and then ran through anomaly detection algorithms and presented in a report and on graphs.





CONCLUSION & FUTURE WORK

The sensor monitoring system detects and monitors all the sensors in the TIPPERS building for anomalies in the data. This is accomplished by anomaly detection techniques that analyze the data directly from the building and present the data to show the details of the anomaly. This system is useful to ensure the functionality and accuracy of the sensors in an IoT environment. The same system can be applied to other IoT Spaces. Future work includes creating anomaly identification algorithms that identify the causes of each anomaly, implementing learning into the anomaly detection algorithms which will allow for a faster implementation of the system and quick addition of new sensor types. As well as incorporate more anomaly detection methods based on the nature of the data to make the system more reliable.