Neural Graph Formulation for Visitor Activity Summarization

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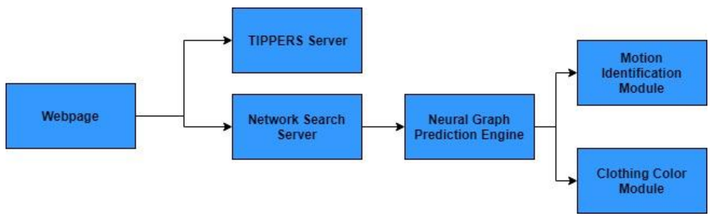
INTRODUCTION

The primary goal of this research project was to develop a system capable of efficiently harnessing the sensor infrastructure of a connected building to generate a sensor oriented summary of a user's day. To achieve this, a neural sensor network capable of predicting the motion of a person moving through Donald Bren Hall and summarizing user related sensor data was developed. Around this prediction engine, several other components were developed, including two computer vision modules and a web application. The theory and implementation used in this project can be applied to a variety of sensor network problems, and is optimized for distributed systems. This research project is part of the wider TIPPERS effort. TIPPERS stands for Testbed for IoT-based Privacy-Preserving PERvasive Spaces. It is a DARPA funded program that explores the methodologies, technologies, and frameworks needed to harness the power of ubiquitous sensors in working spaces without jeopardizing the privacy of its occupants.

CHALLENGES

- **Reduce** the amount of camera footage to be analyzed with computationally expensive computer vision algorithms.
- **Combine** the unique abilities of both wifi and camera sensor types to create a full picture of what is occurring.
- **Create** a generalizable model of sensor relationships.

SOLUTION OVERVIEW



Record Gathering Process

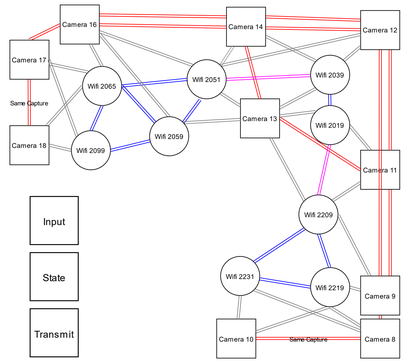
1. User Enters Time Range, Net ID, and Clothing Colors.
2. Webpage requests wifi connections with that Net ID from the TIPPERS server.
3. Webpage triggers the neural graph prediction engine with the first wifi record.
4. The prediction engine gathers and returns photos of the person until the trail is lost
5. Until there are no wifi connection records left, the webpage continues to restart the prediction engine process and receive the results.
6. When finished, the webpage displays all wifi and camera sensor records found.

NEURAL GRAPH REPRESENTATION

Benefits of neural graph representation

- **Distributed deployment** and operation for low connectivity environments.
- **Autonomous** and ad-hoc construction using machine learning.
- **Easy integration** of different sensors due to sensor agnostic interface.

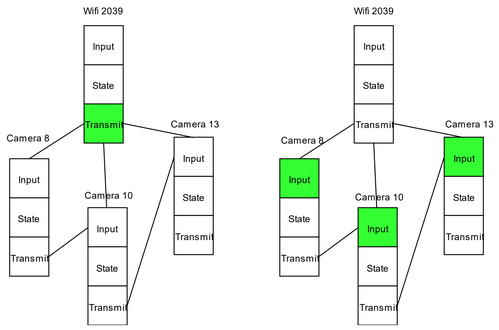
Sensor network represented as node-edge graph



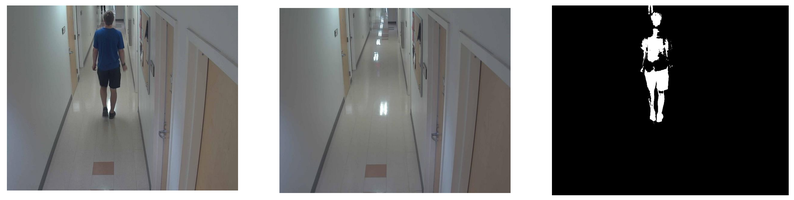
Each sensor represented as a node with a three neuron substructure

TRACKING PROCESS

1. User detected on sensor
2. Sensor captures/stores user data.
3. Sensor loses track of user.
4. Transmit neuron fires (Left image)
5. Connected sensors triggered. (Right Image)
6. Sensors with firing input neurons check for the user.
7. Repeat until trail is lost.



COMPUTER VISION

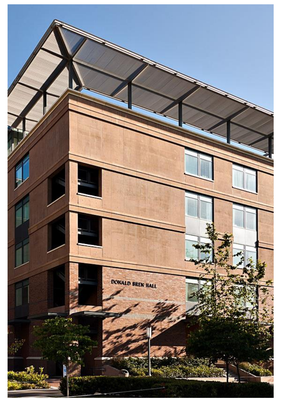


Checked Image - Background = Difference

Two Stage Computer Vision Analysis:

1. Quick check for motion using background subtraction. (Above)
2. More time consuming check for user among detected persons if there is any motion.

TIPPERS



Donald Bren Hall in UCI

TIPPERS is an internet of things(IoT) testbed at the University of California, Irvine. It is housed at Donald Bren Hall.

- Over 300 sensors
- Suite of IoT Applications
- Data Management and Storage Engine
- Privacy Policy Database

WIFI Logs

Video Cameras

WEB INTERFACE

- Interactive summary of a user's time in Donald Bren Hall
- Sensor records of user displayed in table
- Playable video of recorded images.
- Easy to use guided user interface (GUI)
- Records displayed progressively as they are found.

FUTURE WORK

- Improved computer vision capabilities.
- Automatic Pairing of MAC address and image
- Self Constructing Network
- Uses of the neural architecture for other projects.