Tracking the motion in an indoor environment using Wireless Sensor Networks

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***Abstract*— The main aim of the paper is to provide a design architecture that allows for tracking the motion of object in an indoor environment using Wireless Sensor Networks using a Distributed Computing Model. The model uses Raspberry pi B+ and camera Module V2 for Rpi at each node in the Wireless Network.**

Keywords—Distributed Computing Model; Raspberry pi B+;

I. Introduction

The advance of urban infrastructures increases our ability to collect, analyze and utilize big infrastructure data to improve urban phenomenon modeling. Numerous data-driven models have been proposed based on these infrastructure data to capture urban dynamics. However, although each infrastructure produces abundant data, almost all resultant models suffer from data sparsity. Cyber-Physical Systems (CPSs) combine low-power radios with embedded processors to provide high resolution sensing and actuation over a geographic area. Computer Scientists believe that Cyber Physical Systems has had a huge impact in Home Automation Systems and provide a smart home for the future.

Our Work primarily focuses on collection of data from several nodes regarding the motion of a specific object to be tracked and transmitted to a Master Node that makes further decisions based the data received. We approached the scenario with a distributed computing model. As the advancements in the ubiquitous systems with embedded technology has given rise to several low-cost and low power System on Chip (SoC) processors, we place a small compute block along with each sensor. Legacy methods involved the accumulation of the data before handing out the result. The data collected by the sensors is moved to a master node to obtain a intermediate result. This partial result enables the network to make further decisions.

The distributed computing model reduces the communication overhead and the maintenance cost. It provides better fault tolerance as the result can be verified at each node. Unlike the previous model this is independent of the master node. Hence more reliable.

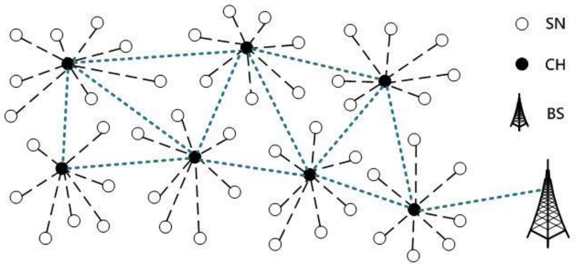


Fig. 1. Wireless Sensor Networks

The key to the Raspberry Pi is initial simplicity with a high tolerance for increasing complexity. For IoT applications, PubNub Data Streams bring this same usability to inter-device communication, enabling even a beginner to create Realtime, bidirectional communication between their own embedded devices. The evaluation results show

II. Methodology

A. *Distributed wireless camera network:*

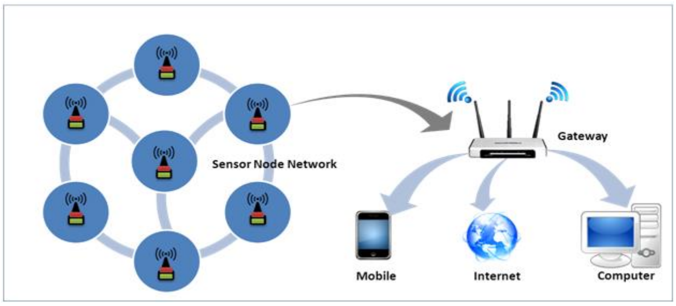


Fig. 2. Camera Network

The System is designed based on this model of integration of various nodes and from the data obtained from different nodes of the wireless Sensor Network as illustrated in figure 2. The system involves the following works and focuses on these aspects for the betterment of the detection estimation.

- Detection of the person at a node and establishing communication between the node that corresponds to the objective field based on the motion of the person.
- By scaling this to multiple nodes, a network of nodes will be created. This can efficiently monitor the direction of motion and the traversal route within the network.
- By computing locally and routing the information to only the node that corresponds to the direction of motion the communication overhead is reduced.
- Also, the overall energy spent at monitoring is reduced.

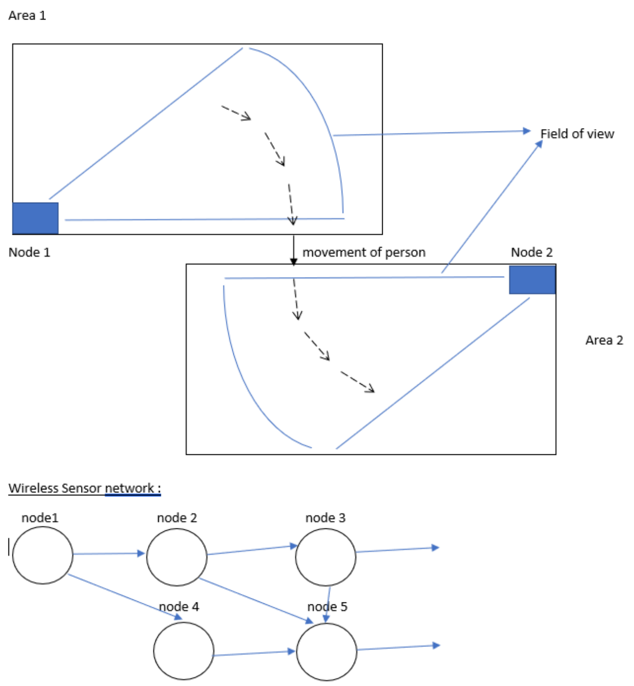


Fig. 3. System Functional Diagram

The Nodes in the Wireless Sensor Networks are connected to each other based on a historically used Mesh Network that integrates each node. Each Node Specifically consists of

Raspberry pi 3 model B+:

1. Processor speed: 1.2 GHz
2. RAM: 512Mb
3. Workbench: Raspbian

Camera module V2 for Rpi.

8 MP, 60 FPS at 720p

We mainly used these components for the sole reason that they are easily available, off the shelf components and in an urban scenario can be retrofitted very easily.

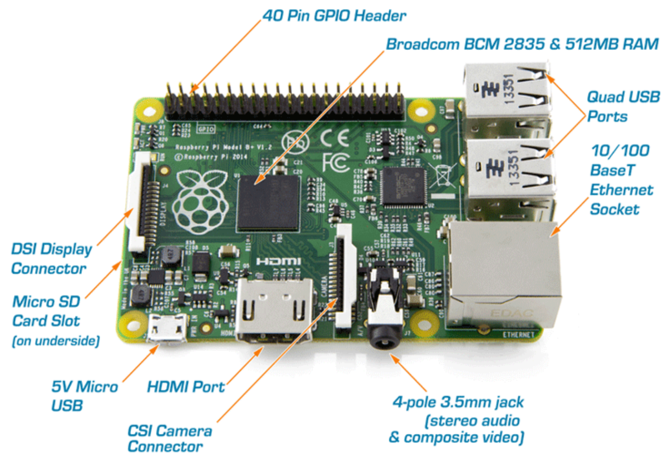


Fig. 4. Raspberry pi 3 model B+

B. Detecting people with HOG detector:

Our System uses a Machine learning algorithm abbreviated as histogram of oriented gradients which is prominent method used in computer vision and image processing for object detection. The technique employed using this algorithm simply counts the occurrences of gradient orientation in localized parts of an image. This method is like that of edge orientation histograms and shape contexts, but differs in that it is computed on a dense grid of uniformly spaced cells and uses overlapping local contrast normalization for accuracy. To account for changes in illumination and contrast, the gradient strengths must be locally normalized, which requires grouping the cells together into larger, spatially connected blocks. A descriptor is created based on many sample Images. Based on distribution of intensity gradients or edge directions. Works perfectly well with cluttered environment as illustrated in the figure 5.

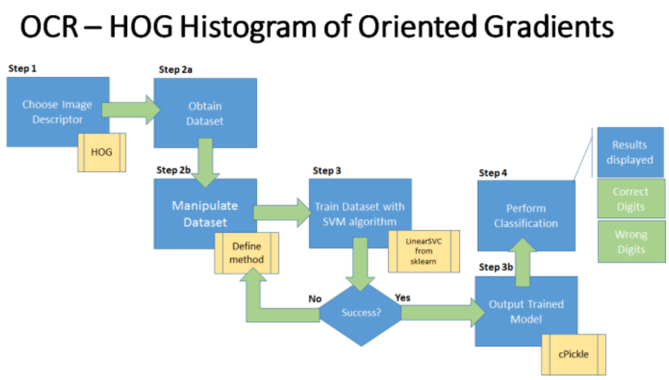


Fig. 5 System Workflow

C. Communication Between Nodes

The Nodes are connected to each other using a Wi-Fi Network wirelessly. The usage of Wi-Fi over other forms of interconnection is attributed to its existence in almost all residences today and enables reusability. The use of Bluetooth, Radio frequency modules can also be implemented but simply increases the modules/node, therefore increasing the system complexity and cost. The main advantage of this Distributed Wireless Camera Network is that each node is used efficiently with an intelligent embedded algorithm that runs through the nodes. With Wi-Fi and specific addresses, the Raspberry Pis' can communicate with each other over TCP/IP - or in other words, "over the Internet".

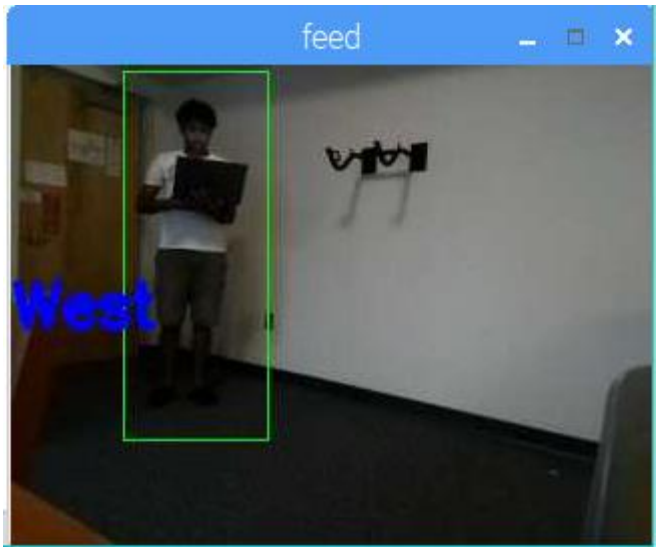
III. Discussion

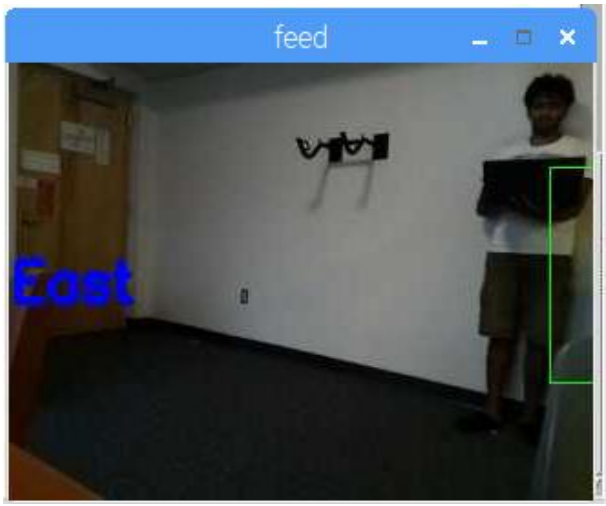
The system was designed with the above hardware and a python script for processing, communication and detection estimation based on Histogram of Oriented Gradients. The functionalities of a node were achieved using Raspberry pi and a camera module. The information is collected in real time and the presence of a person is detected. The direction of motion of the person is successfully tracked. A communication channel was established between two Raspberry pi's. This communication function will later be scaled throughout the network.

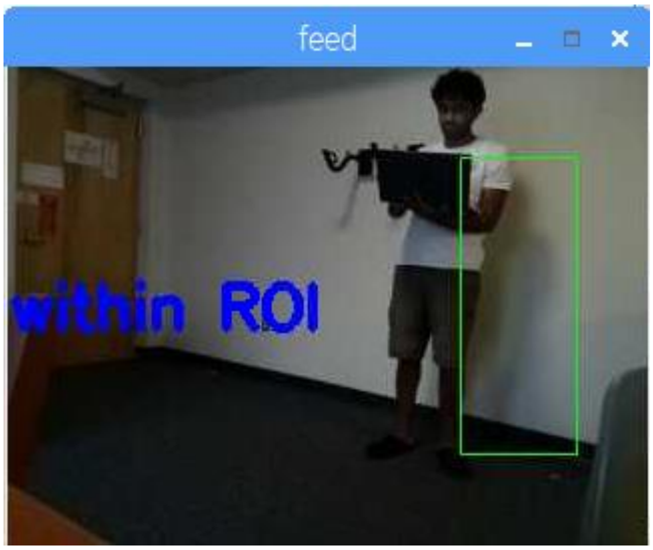
Another work is using a GUI to monitor the output recorded by each node needs to be built. Improving the feature selection and extraction so that this model can be deployed in a crowded environment.

Conclusion

The information is collected in real time and the presence of a person is detected and are depicted as shown below.







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