INDIAN INSTITUTE OF INFORMATION TECHNOLOGY NAGPUR

A Project Report

on

Smart Local Positioning System

Submitted for partial fulfilment for the degree of

Bachelor of Technology

in

Department of Electronics and Communication Engineering

(2017 – 2021)

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Declaration

I hereby declare that the work reported in the B.tech report entitled "Smart Local Positioning System" submitted at Indian Institute of Information Technology, Nagpur India, is an authentic record of my work carried out under the supervision of Dr.Tapan Kumar Jain. I have not submitted this work elsewhere for any other degree.

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Acknowledgements

We would like to express our gratitude to one another at 'LPS' involved in the development and guidance in this project. First of all, we would like to thank to our project supervisor - Dr. Tapan Kumar Jain for telling us about the local positioning system using as local guide in campus. He supported us every time.
We are highly indebted to all faculty members of IIIT Nagpur for their guidance and constant supervision as well as for providing necessary information regarding the project & also for their support in completing the project. We are also thankful to Ankit Vohra, for his timely help in making the convolutional neural net model.

Abstract

It is but natural to find difficulty in navigating through a relatively unknown place. This issue arises in the places like Malls, Institution Campuses which are not as large to be navigable by GPS. Negligence of this issue leaves visitors frustrated while searching for destination. We present a compact model of local positioning system, in which the task to identify the input image of the current location and output the most optimum path to the given destination. We first upload image with the help of a local server on a web portal, which we process with the help of complex convolutional neural network. The predicted label is feeded to the Dijkstra's Algorithm, which will thus give the most optimal path from source to destination. We have achieved nearly 90% accuracy on prediction of the input images using MobileNet Architecture along with the traditional 7 layer CNN.

Chapter 1

Introduction

1.1 Conventional Navigation systems in Use – "Global Positioning System"

GPS is widely used nowadays for Outdoor Navigational Purposes. By "Outdoor Navigation" we mean, navigating thru a geographically large areas like a town, or a locality within a city. We enjoy a hassle-free travel with the aid of GPS in a seemingly unknown place. But it does not always happen that we need aids like GPS in outdoors only. Relatively smaller geographical areas like Shopping Malls, Multiplexes or even tourist marketplace, are also unknown to a first-time visitor. Does GPS work in theses places too?

1.2 The need of an alternative - indoor inoperability of GPS

It is but natural to find difficulty in navigating through a relatively unknown place. This issue arises in the places like Malls, Institution Campuses which are not as large to be navigable by GPS. For ex :

We cannot use GPS to find path from Main entrance of IIIT Nagpur to the Library on 2nd floor. One of the Major disadvantages of GPS is its inoperability in Indoor places. Negligence of this issue in many places leaves visitor in frustration while searching for destination

1.3 A Modern "Smart" Solution – "Local Positioning System"

Implementation of local navigational system based on Raspberry Pi hardware backend and using local resources like CCTV Images and Wi-Fi Networks. NO DEPENDENCY ON INTERNET ! – The Main advantage of LPS is, it uses the EXISTING Infrastructure like WiFi networks present within malls and campuses. Mall Owners may also provide product suggestions based on the shopping list of customer to guide him in shopping in least possible time. Savings in time while shopping leads to Happy Customers. In case of large Institutional Campuses, a local positioning system is a boon for outsiders. Its just 3 Step process for users :

- Login into Campus Wifi as "Guest"
- Click Photo of where the user is and enter the destination.
- Click the Send Button.

And That's it! User gets back a Map on which the path is plotted.

Chapter 2

Literature Review

After advent and the overwhelming success of the GPS, many researchers explored the possibility of an analogous system but localised to a geographical area. Many works exist in literature, which have researched this topic very seriously. A Huge variety exists amongst them based on the “Communication Principle used”, “The Target Object”, etc. Many Communication Principles like Infrared Light, WLAN, Ultarviolet Light, RFID have been used. Indoor navigation system can also be classified based on their purpose like Object Tracking and Detection, Navigational Facilities, Robotic Navigation, Animal Tracking, etc. Some of these are as follows :

2.1 Indoor navigation assistance with a Smartphone camera based on vanishing points [?]

- Input Type : Video Stream from a Smartphone Camera.
- Output Type : Real Time Navigational Instruction.
- Purpose : User assistance in Local Navigation.

- Brief Description : User captures a live video stream which is then compared with pre-stored images of that place.In this way correct real time navigation is provided to user

2.2 Indoor positioning for moving objects using a hardware device with spread spectrum ultrasonic waves [?]

- Input Type : “Spread Spectrum” Ultrasonic Waves.
- Output Type : Distance of Receiver from the Transmitters.
- Purpose : Object Tracking and Detection.
- Brief Description : Transmitters placed all around the room emit Ultrasonic Waves. Receivers picks them up and Calculates the distance from transmitter to receiver based on “Time of Flight” of the waves.

Chapter 3

Methodology

This section of the report discusses the intricacies of the developed system. The section is divided into 4 major parts and explained part by part in detail Below is the proposed methodology flowchart of the Local Positioning System.

3.1 Uploading the image on the web server

3.2 Classification of Images

It is of utmost importance that the system recognise the location of the image getting uploaded so as to show the correct route from source to the destination.

The first choice for designing a robust algorithm automatically shorts down to Convolutional Neural Networks (CNNs). CNNs have wide applications in image and video recognition, recommender systems and natural language processing. CNNs, like neural networks, are made up of neurons with learnable weights and biases. Each neuron receives several inputs, takes a weighted sum over them, pass it

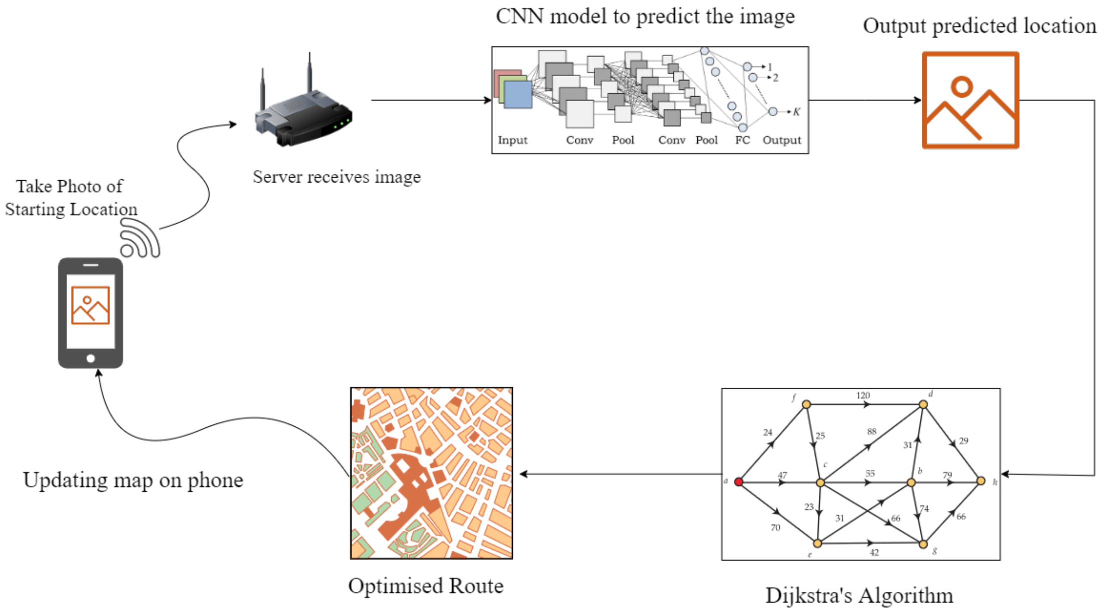

Figure 3.1: Proposed Methodology

through an activation function and responds with an output. ConvNet architectures make the explicit assumption that the inputs are images, which allows us to encode certain properties into the architecture. These then make the forward function more efficient to implement and vastly reduce the amount of parameters in the network.

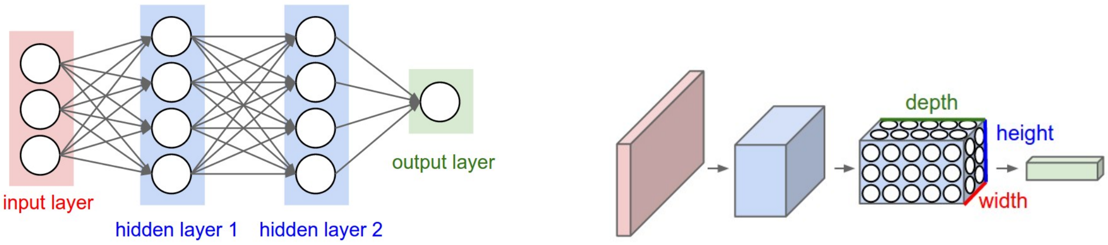

Figure 3.2: CNN Architecture Overview

A simple CNN architecture can be described as follows:

- INPUT [32x32x3] will hold the raw pixel values of the image, in this case an image of width 32, height 32, and with three color channels R,G,B.

- CONV layer will compute the output of neurons that are connected to local regions in the input, each computing a dot product between their weights and a small region they are connected to in the input volume. This may result in volume such as [32x32x12] if we decided to use 12 filters.
- RELU layer will apply an element wise activation function, such as the max(0,x) thresholding at zero. This leaves the size of the volume unchanged ([32x32x12]).
- POOL layer will perform a down-sampling operation along the spatial dimensions (width, height), resulting in volume such as [16x16x12].
- FC (i.e. fully-connected) layer will compute the class scores, resulting in volume of size [1x1x10], where each of the 10 numbers correspond to a class score, such as among the 10 categories of CIFAR-10. As with ordinary Neural Networks and as the name implies, each neuron in this layer will be connected to all the numbers in the previous volume.

In our model, we are considering 4 classes namely Volleyball Ground, Administration Block, BSNL Auditorium and Hostel & Mess Block. Each class has a set of 260-280 images each. The CNN model is made using MobileNet Architecture. For demo, a classification of 4 labelled classes is performed achieving a validation accuracy of 90%. The CNN model is saved in a '.hdf5' file. The accuracy can be further improved by separating the images of trees popping up in both Volleyball Ground dataset and Hostel & Mess Dataset.

Tools Used : MATLAB, Keras, Tensorflow, OpenCV, Numpy, Pandas, Scipy, Scikit, Matplotlib, Python.

3.3 Optimising the route

3.3.1 Usage

For Finding Shortest path from the Queried Source to Destination.

3.3.2 Introduction

This is a very well-known algorithm from “Graph Theory”. It was conceived by computer scientist Edsger W. Dijkstra in 1956. Dijkstra’s original algorithm found the shortest path between two given nodes but a more common variant fixes a single node as the ”source” node and finds shortest paths from the source to all other nodes in the graph, producing a shortest-path tree. In our Work we use the Implementation of the Common variant, since this saves the time in calculation of the other paths.

3.3.3 Brief Description

Programming Framework Used: Python 3 (No extra Libraries)

Input :

1. System needs 2 inputs to work:
    - Source Label
    - Destination Label
2. The former is obtained upon the application of the Deep Learning algorithm on the image clicked by the user.

3. Latter is given directly by user at the time of sending the request for shortest path.

Output :

1. A Python "List", containing the labels of the locations, in ordered sequence, which forms the "Shortest Path" from source to Destination.
2.

Working :

1. Based on "Pre-Stored" graph representing the various location in the campus, "Shortest Path Tree" is derived, which contains the shortest paths from all the nodes to every other node.
2. From that, the shortest path from the queried source to destination is extracted and returned as a "List" datatype, containing labels of all the nodes contained in that path.
3. This list is then used as input to map plotting algorithm, which plots this path on the campus map.

3.4 Implementation

To be able to receive and send information regarding location of the user over the network we have setup a server on the local network. It runs at the heart of the project ensuring seamless flow of information and control to each part of project. We have used the Flask module of python to create the server. The server at the root location serves

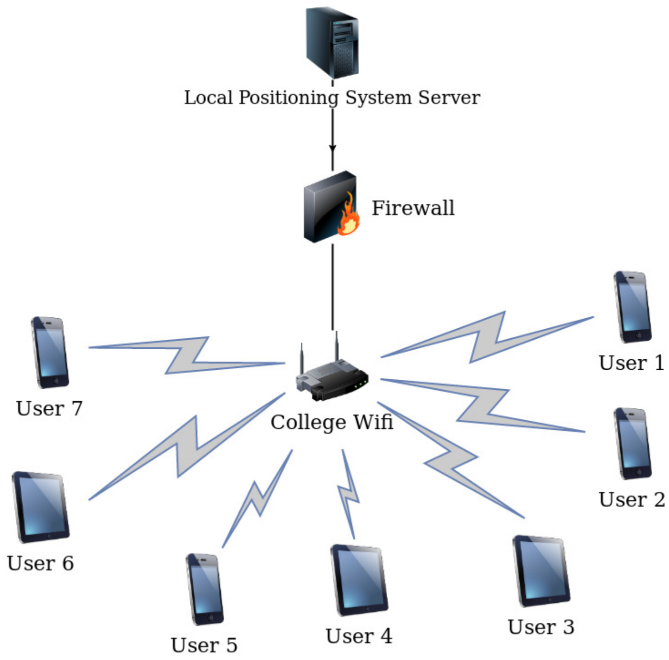

Figure 3.3: Topology of LPS Network

a web page with the option of uploading the image and selecting the destination where the user wants to go. Then the server receives the image and other information given by the client/user and feeds it to the deep learning model for prediction of the location of user. Since the server itself is a heavy process to run, we used a different process to run the deep learning model. Once the deep learning model gives the most probable location, the server then fetches the destination given by the user, and feeds it to the Dijkstra's algorithm (shortest path algorithm) to find the shortest path. Using this path the server then send a graphical representation of the path on the map of the campus back to the user. All of this happens within milliseconds and the user can now find his way to reach where he wants to go.

Chapter 4

Results

LPS will make the customer feel comfortable in large and unknown places. Malls, Tourist places which remain uncaptured by GPS, can now be navigated through our system. The problem of "Visitor Tracking" in gargantum places like Institutional Campuses, Government Offices will be solved.

Ease of interface and lightweight model results in faster accessibility and comfortable use. Importance of CNN for image classification is observed. Further, contribution of the system to Industry 4.0 is realised.

Figure 4.1: Uploading photo on Server

```
[5] 0: Admin_Block
    1: BSNL_Auditorium
    3: Volleyball_Ground
    4: Hostel_Mess
     """
    img = cv2.imread('LPS_v2/grnd/0001.jpg')
    img = img/255.
    classes=model.predict(np.expand_dims(img, axis=0))
    a=np.argmax(classes)
    plt.imshow(img);
```

```
Predited Image is Volleyball Ground
```

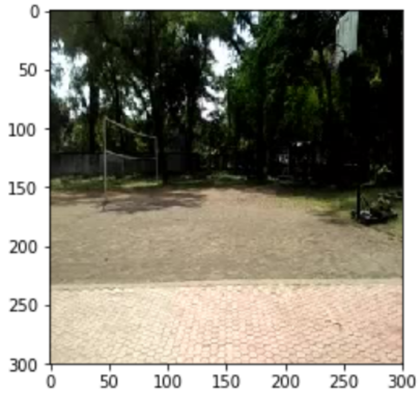

Figure 4.2: Predicted Location

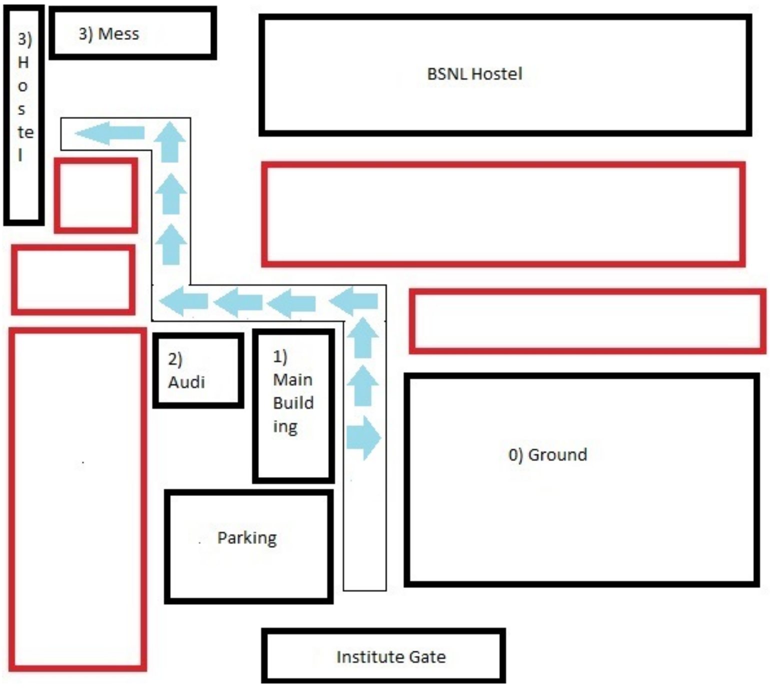

Figure 4.3: Optimised Route on Map

Chapter 5

Conclusions and Future Work

It can be seen that there is a lot of intricacies which have not been covered in our project so far. Though it makes sense for larger computations on a proper CPU, Raspberry Pi can still make up for it easily for a system of this calibre. It will be interesting to observe what happens when the number of locations in the map is increased from 4 to 100 or 1000. That time, Dijkstra's Algorithm will show its real use, as the number of paths to a destination will exponentially increase. This is a proper system which can be implemented in large hospitals, institutes, malls, offices, etc.