SSARSC

Scientific Society of Advanced Research and Social Change
SSARSC International Journal of Geo Science and Geo Informatics
Volume 3 Issue 1, August 2016, ISSN 2348-6198

Tracking and Surveillance using Internet of Things & GIS

Harsh Saxena[1],Megha Goel[2], Safal Arora[3], Nisha Aggrawal[4], S.N Rajan[5]

[1]IMS Engineering College, India (Corresponding Author)

[2, 3, 4]IMS Engineering College, India

[5]Associate Prof. IMS Engineering College, India

***Abstract*—The technology Internet of Things (IoT) provide advanced services to users helping them to optimize operations, reduce costs, boost productivity and improve lives. In this paper, we design an independent network of devices such as- exposure system, smart phone, and server database communicating over network enabling user to follow and supervise the exposure system on a platform independent application. In particular, the exposure system is contained with localization and image capturing capability. Exposure system captures the images of its surrounding and sends these images and geo-spatial information on server. Server processes the geo-tagged images and generates point cloud of these images. Mobile application reads this geo-spatial information from server, and maps the exposure system on Open Street Map. The proposed system has been designed to be easily extensible to other IoT networks and technologies and has application in the tracking, surface reconstruction, Landslide monitoring, and development of 3D Street View.**

***Index Terms*—Point cloud,wireless communication.**

I. INTRODUCTION

The Internet of Things(IoT) is an independent network of physical devices over which these devices can communicate to each other, send data over network, perform operations with minimal human interaction. These physical devices may include human being as a node in this network. In IoT objects are equipped with microcontrollers, sensors and various software applications and with suitable protocol stack they are able to talk to each other.

We thank to the "Tevatron Technologies" for their guidance and support in the field of Electronic and Embedded System and our deepest gratitude is to our advisor, MrMayank Sharma, Junior Research Fellow, PRSD (Photogrammetry and Sensing Department), Indian Institute of Remote Sensing, Dehradun. We have been amazingly fortunate to have an advisor who gave us the freedom to explore on our own and at the same time the guidance to recover when our steps flattered out of his busy schedule.

Internet of Things has been most closely associated with machine-to-machine (M2M) communication in manufacturing and power, oil and gas utilities. Products built with M2M communication capabilities are often referred to as being smart. The Internet has turned into a massive surveillance tool. We're constantly monitored on the Internet by hundreds of companies -- both familiar and unfamiliar. Everything we do there is recorded, collected, and collated -- sometimes by corporations wanting to sell us stuff and sometimes by governments wanting to keep an eye on us.

II. LITERATURE REVIEW

Internet of Things is an emerging field in today's digital world. Everything is making use of autonomous technology. Internet of Thing helps various devices to exchange data over a network to communicate with each other.

A. *PhoneGap*

Phone Gap is a framework that makes the developers develop their apps using standard web APIs for all major mobile operating systems. It is open-source and free.Developers only need to know web development using HTML, CSS and JavaScript. Phone Gap takes care of rest of the work, such as look and feel of the app and portability among various mobile OS.

Using Phone Gap, one can create apps for all major mobile OSl like Apple iOS, Android, BlackBerry, Windows etc. This does not require the developer to have expertise over any of the above mentioned platforms neither the developer is required to know programming to code the app from scratch.

B. Camera Calibration

Camera Calibration is a necessarystep in 3D computer vision in order to extract information from 2D images. The camera calibration module standardizes the camera and estimates the interior orientation parameter.

Purpose of camera calibration is to ascertain projection from 3D world coordinates to 2D image coordinates.

C. *Point Cloud*

A point cloud is a set of points on images that are geo tagged and generated through superimposing the 2D image over each other.

Point cloud could be used in various areas. Point cloud generates 3D image from a set of 2D images. The 3D image thus generated could be used in landslide area for the monitoring of the hilly areas. This could also use for the monitoring of the illegal construction in posh areas.

III. Proposed System

Various existing system are able to track in real time. This proposed system is an extension to the existing systems. The proposed system is able of tracking, surveillance as well as generates 3D structure of its surrounding.

The proposed system consistsof three subsystems. First system is the hardware part which captures data such as, latitude,longitude,date,time and images of the surroundings. A mobile is fixed on the exposure system which captures the surrounding view. An IP is provided to that mobile phone. The system is now controlled using Dual Tone Frequency Module(DTMF). Second subsystem is the server site where exposure system sent all the data captured. Third system is the platform-independent application thatcan track and monitor the exposure system from anywhere. Images could also be uploaded from the application. The images thus uploaded are used to generate the point cloud with help of the algorithms for point cloud generation implemented on the server site.

The functionality of the point cloud generation makes this proposed system different from other systems that are able track and surveillance.

IV. Application of the Proposed System

The proposed system in this paper has application in different fields. Some of the applications are discussed below:

A. Smart Emergency Service System

Everyone will be monitored using smart watch by their doctor and there will be less cases of being late by ambulance in road accident which sometime cost people's life.

It could help in emergency situations when the disaster occurs in multi level structure like building then disaster not only affect the buildings only but these can affect entire whole structure like the emergency help such as medical, police, fire etc according to the situations. Then this 3D street model will help to achieve the real time emergency help and to cop up the situation.

B. Surface Reconstruction

In this, the information about the particular building or floor of the building is saved in its segmentation, due to which it can calculate the loss after any disaster and how can recover from the loss

C. Urban Planning

The population is increasing tremendously and they prefer to live in the cities. Due to this, it would create the hazardous loss to the environment. So this system would help in for visualizing the new city before its development and could also help in monitoring of the illegal construction.

D. Human Centric Intelligence System(HSIC)

Every people will be connected to every other people, everyone will be under surveillance by doctors, traffic authority, Municipality etc., and everyone will be sharing information over internet for better livelihood.

E. Augmented Reality

It is a technique, in which real and virtual environment can be mixed that is very useful for human interaction and real life navigation. So the combination of Augmented Reality and Photogrammetric opens up new possibilities in the field of 3D data visualization, navigation.

V. Methodology

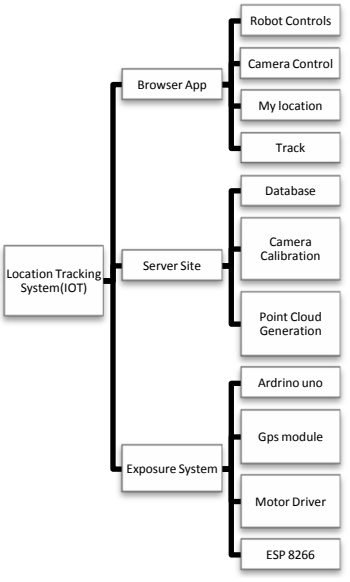

Fig. 1 Model View of Proposed System

A. *Exposure System*

For the exposure system we have assembled various components like Arduino Uno Atmega328 which is a microcontroller. This is interfaced with various other components and it works at 5v.The other component is our Motor Driver L293D which is also interfaced with Arduino. This Motor Driver will help us to control the exposure system by giving different inputs to the motors through Arduino to control its direction. Also we have used the Wi-FI module which is ESP-8266 which is The ESP8266 ESP 01 is a Wi-Fi module that allows microcontrollers access to a Wi-Fi network. The ESP-01 acts as a small computer. Depending on the version of the *ESP8266*, it is possible to have up to 9 GPIOs (General Purpose Input Output). Thus, we can give a microcontroller internet access like the Wi-Fi shield does to the Arduino, or we can simply program the ESP8266 to not only have access to a Wi-Fi network, but to act as a microcontroller as well. This makes the ESP8266 very versatile, and it can save some money and space in our project.

B. *Mobile Application*

This component, connecting exposure system and server database, is a platform independent application.This app is developed using PhoneGap i.e. the application is cross platform and can be built for different devices such as Android device, iOS, Windows phone, or PC browser. The application retrieves the data from the server and maps the current position of the exposure system on the maps. Mobile application is fetching the device location through server and tracking the system on the Open Street Map. This application is divided into four modules:

1) *In Location module,*
   i. This module's purpose is of tracking.
   ii. Application is fetching location data of exposure system from server and displays its coordinates on the device.
   iii. This part allows user to track the system live from anywhere using any device or even it on browser.
2) *In Map module,*
   i. This module is the second part of the Location module.
   ii. Application is fetching location data of exposure system from server and displays its coordinates on a map.
   iii. In this module we are using the leaflet API for the map.
   iv. For data fetching we are using Dirt-Simple HTTP API.
3) *In Rolling module,*
   i. This module's basic purpose is of surveillance.
   ii. Our exposure system has a camera, which is accessed through an IP address on the application's web browser.
   iii. This part also allows user to click the image and/or video of the surroundings of the system.
   iv. An IP will be provided to the application that will capture image and send those images to sever database.
4) *In Upload image module,*
   i. This module is the part of point cloud generation.
   ii. Image that would be uploaded will be submitted through a form.
   iii. On the submission of the form a PHP script will run to upload the selected image.
   iv. Uploaded image will be saved on the server database for the generation of the point cloud.

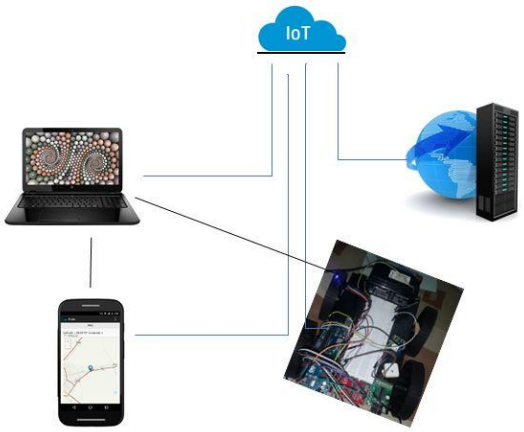

Fig. 2 Pictorial View of Proposed Project

C. *Camera Calibration*

In human being, images are produced by the overlapping of two different orientation and that's why human being feel 3D of the images, the same concept is used here, the digital camera which is mounted over the exposure system captures the images of the target object like building is from different orientation so that multiple images creates the effect of 3D image from the collection of overlapping 2D images.

As we all know the procedure of formation of images. The light from the observer is strike to the target object and then is captured by the camera through the lenses of the camera and the rays which are strike the target object is passed by the lens then hit the image sensor at which the image is created at the

back of the camera. This can be explained by the pin hole camera model. Under this model the important parameters of the camera are its focal length, the field view of the camera and the number of pixels of the image plane. The camera parameter can be extracted from process which is known as the camera calibration.

Now the question arises that what is camera calibration?

Camera calibration is the process by which the different camera parameters are obtained. We can use the specification of the camera manufacturer but at this point we required other important parameters also for the generation of the 3D structure of the targeted object. The manufacturer specification is not enough to create the 3D structure. This can be easily done by the function which is defined under the OpenCV calibration functions.

For the calibration, we require chess board pattern images because it generates the 3D scene points and has only two colors such as white and black.. As the chess board images are 2D images, in this we do not have Z axis so that Z =0 and with X and Y axes which are aligned at the different angles.

The OpenCV function detects the corner of the chess board images by providing the input as the images and the size of the images. It will provide the output the corner of the images. If this function fails then it will return false. After detection the corner, it'll provide vector list of the detected points, which would be the input of the camera calibrator class. In this we have to click the 7 to 8 images minimum required of the chess board at the different orientations and at different depth for the computation of the camera parameters of the image.

Good calibration is needed when want to reconstruct a world model, 3D interpretation of the image and interaction with the world. Here, the user finds out the exact parameter of the camera with the help of photograph. The parameter of the camera can be represented in the matrix of the order of 3 x 4 which is known as camera matrix. This is the reason that's why called it camera calibration or can say it photometric camera calibration. It is used to determine the intrinsic and extrinsic parameters.

Extrinsic Parameters [R|T]: In this, it would define the location and orientation of the camera with respect to the world frame. It depends only on the position of the camera. There are two parameters such as Rotation and Translation

Intrinsic Parameters (K Matrix): In this, it would map the camera coordinate and pixel coordinates in the image frame. It depends only on camera characteristics like focal length, skew, distortion and image centre. There are five parameters such as focal length (f), Pixel Size in x and y direction (sx in x direction, sy in y direction), Principal point (ox, oy). Usually, take square pixel then sx = sy = s. Due to this assumption it become four parameters.

D. Point Cloud Generation

In this we project the 3D object(X, Y,Z) at the images (x, y) on the camera specified in the pixel coordinates. We can get the 2D images pixel coordinates by the following matrix.

The following matrix are the intrinsic parameter which includes all the camera parameters like f_x, f_y are the focal length of the camera in x and y direction respectively expressed in pixel units and u_o, v_o are the principal point that are the image centre and the projection matrix that gives a vector space projection.[1]

$$s\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} f_x & 0 & u_0 \\ 0 & f_y & v_0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} f_x & 0 & u_0 \\ 0 & f_y & v_0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

In the point cloud generation, we would use the Bundler and PMVS algorithm. It will use the structure from motion (SfM) algorithm. This algorithm calculates the relative position of 3D spaces from the photographs with this. Bundler is the first algorithm which is applied to generate *point cloud*.

Bundler: It is SfM system for unordered image collection. In this, it would take the input like set of image, image features and images matches and will produce the result a 3D reconstruction of the camera and scene geometry. It would run on a collection of images i.e. 3 images is minimum required. Bundler contain the useful implementation algorithm like

F-Matrix Estimation: F matrix is fundamental matrix of 3x3 which relates the corresponding points in the stereo images. It is a relationship between any two images of the same object that constrains where the projection point occurs in both images

Calibrated 5 Point Relative Pose: It is to find all possible camera configurations between two calibrated views of an image given exactly 5 point correspondence.

Triangulation of multiple rays: It is a process of determining a point in 3D space given its projection onto 2 or more images

PMVS: It is an acronym of Patch Multi-View Stereo. It takes as input the sparse reconstruction resulted from running Bundler and produces a dense 3D reconstruction. It is software that takes a set of images and camera parameters then reconstructed 3D structure of an object. In this, only rigid structure is constructed, it automatically ignores non-rigid object like it ignores the pedestrians in front of building.

VI. Outcome

The main outcome of this project is the exposure system (fig 3) which is used to take the input images which will be processed in the back end. Another very important outcome is the 3D point cloud of the building which can also be seen in the image (fig 4) given below where we have used the system to take images of our college building block and after the processing we can see the 3D point cloud as the outcome as depicted in the figure given below:

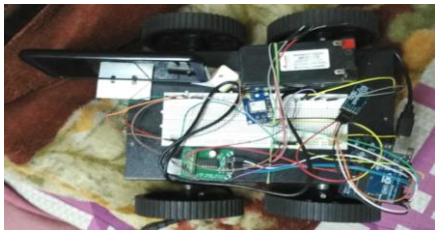

Fig. 3 Iot Based Exposure System

Fig. 4 Point cloud of building

VII. Future Scope

The future scope of the project is augmented reality and surface reconstruction. Augmented reality is that in which the reality is mixed with the virtual scenario, just as game uses the effect. And another application is surface reconstruction through which we can generate the 3D model with the help of triangularity and the mashes algorithm. After the generation of 3D model we can mapped it with the help of geo referenced model into map and then the street view of the map is generated. Also the range of controlling the exposure system can be increased which could be done by using the GSM Simcom module (SIMCOM900).This will help us to access the exposure system from anywhere so that we can take it any location of our interest.

VIII. Conclusion

The project focuses to implement an exposure system using microcontrollers and the concept of *IoT*. The exposure system is taken to a specified location by controlling it remotely. This exposure system is tracked on the map on the Browser application. For surveillance part, the exposure system takes the images of the desired object like building and sends these images to the server, generating its 3D point cloud which can be further used for the purpose of surface reconstruction through which we can generate the 3D model with the help of triangularity, augmented reality,landslide monitoring.

IX. Acknowledgment

We give special thanks to Mr. Mayank Sharma from IIRS,Dehradun, who has guided us throughout our project and also to the Institute IIRS who has provided us with the workspace where we had explored variousopportunities.

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