# Mobile Applications and Web Development Project

## Hochschule Fulda

## University of Applied Sciences

Anil Manzoor

644493

Hassaan Ahmed Rana

944493

Saad Abdullah Gondal

244527

# Abstract

The study presented in the paper by Gopi Krishna Tummala, Rupam Kundu, Prasun Sinha and Rajiv Ramnath, titled ‘’ Vision-Track: Vision based Indoor Tracking in Anchor-free Regions” *[1]*, has been explored, and the concepts defined in the paper have been implemented as understood by the team, to further establish the viability and the feasibility of the said concept. The implementation has been done over the iOS platform, and an iPad was used for deployment. This paper begins by introducing the original paper; henceforth referred to as Vision Track (VT, *Section 2.1*); quoting original text from the said paper, with excerpts from the paper where required. The aim of the research activity; based on the aforementioned activity as perceived and understood by the team; describing the terminologies, is presented, followed by a problem statement and detailed description of the research. Utilized technologies are further presented, followed by the motivation for undertaking this task. Implementation details are detailed. An evaluation of the activity and the outcomes is presented, followed by a description of the contribution to the subject matter and the benefits and learning thus achieved. The paper ends with a short conclusion as perceived by the team.

# Introduction

VT presents a new idea for providing precise tracking services by using a mobile smart camera, in a simple context with some core objectives, presented in the Description (*Section 2.3*). Also, a concept of visual markers is introduced by VT, which enables the system to compute the relative displacement and relative change of orientation from the starting point. QR codes were used as markers in this system, the reasoning for which is further detailed in *Section 2.3*.

## 2.1 Terminologies

* Vision Track (VT) i.e. the original paper and idea, as introduced by Tummala et. all *[1]*
* Visual Light Communication (VLC)
* Radio Frequency (RF)
* Access Point (AP)
* Line of Sight (LOS)
* QR Code (Quick Response Code) *[2]*
* Object Width (W) - Original width of the QR code after it is printed for scanning
* Focal Length (F) - Focal length of the device that is being used for scanning
* Actual Distance (D) - Distance between the device and QR code
* Size in Pixels (P) - The width of the QR code which is perceived by the camera according to the distance from the printed QR code.
* Max Distance (Max\_D) - The maximum distance from which the machine can detect the QR code quickly and comfortably by the user.

## 2.2 Problem Statement

As stated by VT “(...) Conventional WiFi based localization techniques (...) can provide indoor localization with an error of 2-3 m but fails to provide the orientation of the user. A small subset of the RF-localization (...) can provide both location and orientation. But, it requires the APs to be in LOS of the user. Therefore, to provide continuous location services in indoor settings, RF-localization requires dense deployments of APs in the user's field of view, which entails expensive modifications to existing infrastructure. Fingerprinting based approaches (...) require offline training and have a meter level error margin. Inertial sensors can measure location and orientation but they are known to suffer from error accumulation (...). Recent works on VLC (...) encode data in terms of light intensity changes imperceptible to human eyes but can be decoded successfully using light sensors. VLC can enable users with accurate localization services akin to GPS in outdoor environments, only if the VLC-bulbs are closely spaced. So the key question is - *How can we achieve accurate location and orientation information when no anchor point (AP or VLC-bulb) is in LOS?*

Vision-Track is the first vision based solution that can continue to track the camera's location and orientation even when no anchor point is in sight.”

To detect the location of the user from/to a particular point without the use of external components, hardware upgrades, or additional deployment, VT resolves the dependency on external hardware and, in turn, reduce deployment costs. Moreover, as GPS is not accurate in indoor spaces, and fails to give a precise location. VT combines its indoor tracking technique with GPS and compass to provide greatly enhanced location precision.

## 2.3 Description

As mentioned earlier, VT presents an idea for providing precise tracking services with some core objectives. VT quotes: “(...)we aim to provide tracking services by using a mobile smart camera such as in google glasses and smartphones considering the following three objectives: (1) No additional deployment, (2) No user-side instrumentation or hardware upgrades, and (3) Easy adoption in practice. Existing RF or VLC based solutions for indoor tracking can provide location and orientation only when there are dense deployments of APs or VLC bulbs (anchor points) in user's field of view. Vision-Track is the first vision based solution that can track the camera's location and orientation indoors even when no anchor point is in line-of-sight (LOS). Vision-Track deployed in an indoor college building provides a median localization accuracy of 49 cm.” *[1]*

VT proposes to use the GPS coordinates and compass orientation of the user, combined with the power of Vision-Track to precisely identify the user’s location. This paper focuses on the practical implementation and refinement of the relative displacement of the user from a pre-calibrated starting point, as described in the implementation (*Section 5*). This paper takes the concept of the markers introduced by VT a step further, and uses QR codes *[2]* as the marker to provide a rich technique to identify visual locations, with additional information. QR code is a machine-readable code which contains some information that can be used for several purposes. This paper explains the methodology in which the QR code can be used to detect the distance of the user from the point where QR code is placed. This method can help users to find their location within a closed area. This additional feature, vastly expands the capability of the system, and the data storage of the QR code *[3]* can help precisely pin-point the user’s coordinates possibly by storing predefined location coordinates, and may also be used for a vast variety of other data.

# Technologies

The implementation has been done over the iOS platform, with Swift 3.0, using XCode 8, on the OSX platform, version Sierra. In-built library frameworks by Apple have been utilized to access hardware resources on the test device, namely, an iPad Air 9.7 inch.

Research was also conducted over an Android platform using Java, to establish the mathematical formalization as defined in Implementation (Section 5) would serve as a feasible solution to carry out the implementation.

# Implementation

The idea provided by VT involves implementing the logic to scan a physical object placed at a predefined height and then tracking that object using the camera of the device, to first locate the relative position of the user with respect to the marker and then further providing the actual position of the user by identifying the distance of the user from the marker and referencing it with the geographical position of the scanned marker to find the location of the user.

The implementation performed as per this paper, the idea of a physical marker is replaced by a QR Code, this QR Code can either hold the description related to a particular location or some GPS coordinates of that particular location where QR Code is deployed, depending upon the criteria that is to be used to report the location of the user.

The implementation as per now involves providing the ability to the user to scan a particular QR code using the camera in the device and identifying the distance relative to a particular marker. This idea can be extended further by utilizing the QR Codes containing the GPS coordinates and the feedback from the compass (if available in the device), the distance of the user from the marker and the GPS coordinates provided by the QR Code.

The process to identify the distance of the QR code from the device revolves around identification of Focal length of the camera. The application needs to perform an initial calibration to determine the focal length of the camera, this is performed by the user from predefined distance and by referring the width of the marker. This focal length is then used to get the distance of the user from a specific point.

The mathematical formula to calculate the Focal length;

F = (P x D) / W

Once the Focal length of the device is calculated the next step is to utilize this information for every changing frame from an arbitrary distance.  
The exact distance is calculated using the formula;

D = (F x W) / P

## 4.1 Assumptions

As defined by VT, "... For ease of exposition, we make the following assumptions:

* The user is moving in the same floor: This can be relaxed by leveraging the Wi-Fi signature of the user. As the user moves from one floor to another, the change in the Wi-Fi signature can be used to restart the tracking mechanism.
* The height of the camera from the floor is not changing with time: Vision-Track can be coupled with Ultrasonic depth sensing to get the depth. Alternatively, the height of ceiling can be measured using camera by tracking both the ceiling points and the floor points simultaneously. However, the only constraint is we need to know the floor-to-ceiling height (which can be known from most CAD drawings.)
* The orientation of the camera is parallel to the floor, i.e., the camera is looking at a direction parallel to the ground: This can be relaxed by incorporating the gyroscope measurements.
* The ceiling height is uniform: Later we evaluated this assumption of uniformity of ceiling height by studying the error in tracking when there is error in height of ceiling (non-uniform)." *[1]*

This paper extends these assumptions to add some of its own, while implementing further strategies to render some assumptions obsolete, i.e. those assumptions need not be considered anymore, since the system is implemented in a way to overcome them. More details of this can be found in the Implementation (*Section 5*).

It is assumed that the device has an appropriately working camera and the application is installed. For the calibration part, the machine is placed at the specified distance from the marker and is held still for the system to calculate the correct distance. The sensitivity of the scanning depends on the lighting conditions and works best for indoor environments with ample lighting and reduced glare. Sunlight should be minimized as it reduced the sensitivity. The size of the physical object is predefined and is same throughout the scanning area.

# Evaluation

This method greatly reduces the dependency on external components and increases the location tracking from the marker. It was analyzed that the size of the marker W is directly proportional to the maximum distance Max\_D that can be calculated. For our sample analysis, the device location was calculated from different points and by changing the sizes of the marker object. The maximum distance from the marker was recorded. It was observed that with reducing the size of marker by 25%, the maximum distance (Max\_D) was reduced by nearly 2m. Further reducing the original marker by 50% reduced Max\_D by 3.5m to 4m.

As outlined by VT: “Vision-Track deployed in an indoor college building provides a median localization accuracy of 49 cm”. The techniques employed by this paper, further increases the accuracy within 20 cm.

# Contribution and Benefits

This implementation aims to extend the concepts of VT and improve the location accuracy. This has successfully been achieved from a median localization accuracy of 49 cm of VT, upto an accuracy of 20 cm.

VT quotes: “(...) smart-glasses, enhanced smartphone cameras, intelligent security cameras, etc. (...) These features when integrated with the knowledge of location, can benefit many applications associated with indoor navigation such as tracking, vision aid for visually impaired people, object tagging, security and activity monitoring.”

This may further create implementations in the fields of emergency response for locating and rescuing user since the system can store the number of detected users by the QR code deployed at a location and this data can be used to perform visit analysis and also to detect the presence of the number of users in case of emergency situations.

# Conclusion

Through the course of the research and implementation of the topics and ideas presented by VT, it is found with confidence that the concepts of indoor tracking using markers, is a viable and feasible idea. Furthermore, the ideas can be extended to further improve the accuracy of the user’s location, by the integration of modern tools such as QR codes. This technique, when integrated with pre-existing and greatly researched and implemented tools such as GPS and Compass, can provide great accuracy of location. VT sets a target of an accuracy of down to 49cm. The techniques used during the current implementation further improves the accuracy, as defined in Evaluation (*Section 6*).

# References

*[1] Gopi Krishna Tummala, Rupam Kundu, Prasun Sinha and Rajiv Ramnath. Vision-Track: Vision based Indoor Tracking in Anchor-free Regions.*

*[2]* [*https://en.wikipedia.org/wiki/QR\_code*](https://en.wikipedia.org/wiki/QR_code)

*[3]* [*http://blog.qr4.nl/page/QR-Code-Data-Capacity.aspx*](http://blog.qr4.nl/page/QR-Code-Data-Capacity.aspx)