Analysis on Indoor Navigation System Using Augmented Reality

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Abstract--- Global Positioning System (GPS) is a satellite navigation system that displays location and time information in all weather conditions to the user, irrelevant of position. GPS technology uses satellites and ground stations that has made an impact on navigation and positioning needs of common people. It has the ability to track aircraft, cars, cell phones, boats and even individuals that become a reality. These all refer to outdoor navigation that is easily possible with the help of GPS navigation. But if we refer to indoor navigation there comes the use of images and videos. To reach proper Indoor position, we need to use the concept of Augmented Reality over here. In this research work the technology will help us to reach the Indoor position by using images, videos and creating a virtual view in front of users. There has been an upward trend in the requirement of indoor positioning systems using Bluetooth low energy (BLE), Wi-Fi, and visible light communication. Various Centroid Localization Algorithms are used. In this paper, we discuss one of the centroid localization algorithms i.e. Weighted Centroid Localization (WCL) Algorithm using Received Signal Strength Indicator (RSSI) observed from neighboring anchors nodes. The WCL is evaluated in a particular building and analyzed to configure the parameter for real-time location Indoor positioning system.

Keywords--- Global Positioning System (GPS), Indoor Positioning (IP), Weighted Centroid Localization (WCL) Algorithm, Received Signal Strength Indicator (RSSI), Augmented Reality (AR)

I. INTRODUCTION

The system using location is mainly dependent on the technology named Global Positioning System (GPS). GPS is perfectly suitable for outdoor navigation but however it is not practical for indoor positioning because it needs undisturbed reception of signals from at least four satellites with line of sight [3]. If a person visits any building or site for the first time it needs navigation guidance to ease them in finding their destination room in a building. But the current physical navigation signs are often confusing and even misguide in the building [1]. In Order to address this problem a particular system is needed.

Augmented reality (AR) is a variation of virtual reality (VR) [7], but the relationship between real space, virtual space and all the intermediate forms of mixed space have been formalized by Milgram & Kishino in 1994 [8][9]. *Augmented Reality* (AR) is an area of research that aims to enhance the real world by overlaying computer-generated data on top of it [10]. Author identifies three key characteristics of AR systems: (i) mixing virtual images with the real world, (ii) three-dimensional registration of digital data and (iii) interactivity in real time [10][11]. The first AR experience with these characteristics was analyzed over 40 years ago [12], but the main adoption to AR has been limited by the available technologies [10]. Applications of Augmented Reality are as follows: Entertainment likes Games, Robotics, Manufacturing and other industries, Military Training, Engineering Design etc. Various devices are used for implementing AR in it. They are Smart Phones, Tablets, Smart Glasses, and AR Headsets [13].

II. RELATED WORK

Hanas Subakti et al. [1], proposed an interactive guidance system which become interface between guidance system, building environment, and the fresh user. Maps and images of the building, directions, and detailed of specific places or rooms or facilities for helping new students or users to discover way to their department. This system consists of three subsystems. They are the marker-based Cyber-Physical Interaction (CPI) system, the indoor positioning (IP) system, and the augmented-reality (AR) system. The CPI system that is Cyber-Physical System (CPS) which collects sensor data from the real world and links them to various information sources for analysis of current scenario in cyber environment [14]. The author proposed an Android application called Engfi Gate System that is a guidance system. Two operational mode designed in this system. They are Phone mode that helps the new student to explore their building using their smart phone and the Head Mounted Device (HMD) mode that makes the interaction very simple by just placing the smart phone inside the Head Mounted Device without holding the smart phone. Hanas Subakti et al. [2], proposed a guidance system to guide new students, such as freshmen or newly arriving students, to navigate different places, especially buildings, within the campus. This system consists of mainly three subsystems. They are the marker-based cyber-physical interaction (CPI) system, the Indoor Positioning (IP) system, and the

Augmented-Reality (AR) system. Author has designed and implemented a marker-based cyber-physical augmented-reality indoor guidance system, called Engfi Gate, for helping new students to navigate buildings within campus. Author has not yet involved a game server in the Engfi Gate system to provide a virtual environment for cyber users to navigate and interact with physical users. Author is planning to improve the IP system to provide more accurate user position information.

Santosh Subedi et al. [3], proposed a Weighted Centroid Localization (WCL) derived from a centroid determination method where weights are used to estimate position [15]. Demonstration of WCL method that can be used in indoor positioning system with the help of wireless technology known as Bluetooth Low Energy (BLE) is proposed. Author measured the performance of WCL method under the various degrees of weight and obtained that degree of 0.5 is most reliable at the testing environment. This WCL can be joined with fingerprinting to enhance the estimation of the current location. Nizetic Kosovic et al. [4], proposed localization method that counts the difference among various anchor nodes and the client device or receiver. Then it calculates the average signal strength from multiple repetitive measurement, to make the external interference optimal. It can be used with a variety of different low-cost, off-the-shelf Wi-Fi access point devices, does not require any additional or specialized hardware, and uses the features that are widely available on almost every mobile device today. This localization process is totally carried out by software on the user's device only so the location and movement history is only known to user that makes user's detail secure. Author describes that further the improvement in accuracy and quality of locality can be improved.

Quande Dong et al. [5], proposed a weight-compensated weighted centroid localization algorithm (WCWCL) based on RSSI for an outdoor environment. By theoretically analyzing, the proposed algorithm has the advantage of lower complexity, little prior information and lower power consumption. Author analyzed the performance of WCWCL-RSSI algorithm through the number of anchor nodes, the standard deviation and the path loss exponent. The compared results show that proposed algorithm achieves a reduced localization error than WCL and Anchor optimized Modified Weighted Centroid Localization based on RSSI (AMWCL-RSSI). If there are fewer anchor nodes, author plan to work on improvement of the localization accuracy as a future work. Jijun Zhao et al. [6], proposed an algorithm called Weighted Centroid Localization Difference of Estimated Distances (WCL-DED). This algorithm is as an improvement of modified weighted centroid localization (MWCL). The algorithm utilizes the difference of estimated distances to improve the MWCL algorithm. It describes the influence exactly to the anchors nodes, as it has added more information to detect the unknown node. So by making several experiments the algorithm presented over here is better than the MWCL algorithm without introducing any new variable.

III. PROPOSED WORK:

From the above literature discussion, the problem of achieving higher error rates that effect the accuracy of whole system and also increases response time was highlighted among all. So now our task is to make the localization algorithm efficient that can reduce the error rate and decrease the response time. This section presents a proposal to overcome the limitations of the above problems and to make the algorithm efficient.

A. Navigation

Navigation is a field of study that concentrates on the process of monitoring and controlling the movement of a craft or vehicle from one place to another [19] [20]. There are four categories of navigation. They are: land navigation, marine navigation, aeronautic navigation, and space navigation [21]. Apart from this navigation can be done in two manner: Indoor Navigation and Outdoor Navigation.

1. Outdoor Navigation:

Outdoor Navigation means to get a way to reach the destination in proper manner by following a proper path. It is mainly used by outdoor athletes such as hikers, backpackers, geocaching enthusiasts, mountaineers or bikers and outdoor workers such emergency workers, wildlife preservation workers, forestry workers, farmers or mining workers [22]. For outdoor navigation many systems are available such as Global Positioning System (GPS), Global Navigation Satellite System (GLONASS), Galileo or BeiDou. The flow of Outdoor Navigation System is as follows:

As shown in [23] Figure. 1, in the first step user's current position is determined by obtaining position data through geo-positioning sensors and then applying a map matching algorithm using the obtained position data. It is common step, in order to improve the accuracy, availability, and reliability of position data in outdoor navigation systems, we must employ more than one geo-positioning sensors so that they require position data at each position could be filtered, e.g., using a Kalman filter[18] to find the best position estimate. Once the position data is obtained directly or by filtering, it is input to the map matching algorithm where it uses a map database of the traveling the area, which includes spatial and non-spatial data, to find the road/sidewalk segment on which the user is and the precise location of the user on the segment.

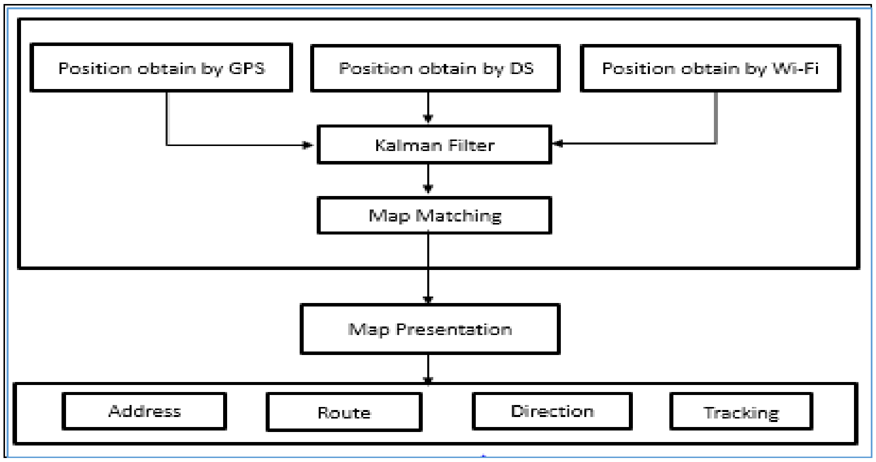

Figure. 1 Flow of information in outdoor navigation systems/services [23]

2. *Indoor Navigation:*

Indoor navigation deals with navigation within buildings**.** Because GPS reception is normally non-existent inside buildings, other positioning technologies are used here when automatic positioning is desired [24]. This system is used to locate objects or people inside a building using lights, radio waves, magnetic fields, acoustic signals, or other sensory information [25]. Indoor positioning systems use different technologies, including distance measurement to nearby anchor nodes (nodes with known fixed positions, e.g. Wi-Fi / Li-Fi access points or Bluetooth beacons), magnetic positioning, dead reckoning [26]. They either actively locate mobile devices and tags or provide ambient location or environmental context for devices to get sensed [27].

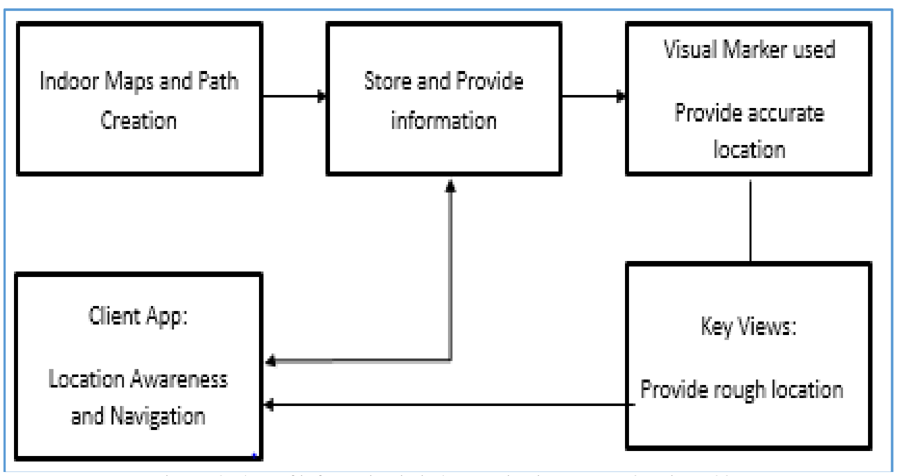

Figure. 2 Flow of information in indoor navigation systems/services [28]

There are various algorithms used for finding the current location of the device or receiver. They are Weighted Centroid Localization Algorithms, Template based tracking, square matric based tracking, etc. We will discuss next the Algorithm.

B. WCL Algorithm

Centroid Localization algorithm is very important in node localization. The received signal strength (RSS) can be used to reduce positioning time [16]. Weighted centroid localization (WCL) is firstly proposed in [5]. Weighted centroid localization has already caused much attention due to their simplicity and robustness to changes in wireless transmission [16]. These various advantages makes this algorithm suitable for every node in the network. The basic idea of weighted centroid localization algorithm based on RSSI is that the unknown node to beacon node RSSI information gathering around them, to receive the data and then separately to each anchor node as the center of the circle, Communication distance for the radius of a circle, then unknown sensor nodes on the intersection part of all round, on the basis of traditional centroid algorithm, for each of the anchor node coordinates, increase the weight, which reflects each anchor node's contribution to the localization process [17].

RSSI Weighted Centroid Localization Algorithm Steps [17]:

If there are n anchor nodes in wireless sensor network, unknown sensor node coordinates is set to (a,b), then the centroid localization algorithm based on RSSI specific estimation steps are as follows:

1) The anchor node send their related information, including their own ID information and position coordinates information into the surrounding nodes in the form of broadcast.
2) Unknown node receives the broadcast information issued by the anchor nodes, to the same anchor Unknown node need to record information broadcast by the anchor node for many times and calculate the average received signal strength of anchor nodes.
3) When the node under test receive anchor node information number more than setting the threshold value of n, We can establish formulas about anchor node coordinates and signal strength Positionset={(a_1, b_1) , (a_2, b_2) ,…(a_n, b_n) } and RSSIset={$RSSI_1$, $RSSI_2$,_ $RSSI_n$}.
4) According to the formula, we can calculate the coordinates of the node under test (a, b).

$$\begin{cases} a=\dfrac{w_1*a_1+w_2*a_2+w_3*a_3+\cdots+w_n*a_n}{w_{*1}+w_2+w_3+\cdots+w_n} \\[2ex] b=\dfrac{w_1*b_1+w_2*b_2+w_3*b_3+\cdots+w_n*b_n}{w_1+w_2+w_3+\cdots+w_n} \end{cases} \quad \text{....... (1)}$$

$$w_i=\frac{RSSI_i}{RSSI_1+RSSI_2+RSSI_3+\cdots+RSSI_n}$$

$$(where\ i=1,2,3,\ldots n)$$

5) Measurement error analysis, the calculation formula is as follows: ERROR _ (a _ a*) 2 _ (b_ b*) 2 the (a, b) is obtained by improved algorithm of unknown node coordinates, the (a, b) is obtained by improved algorithm of unknown node coordinates, (a*, b*) is a true coordinates of the unknown node. The author in [3] describes that WCL is a location estimation technique assigning weight (w_i) to each beacon, based on distance to beacon and degree (g). This algorithm confines location estimation inside the region surrounded by beacons. Since any beacon near to tag device will have highest weight, the final location estimation is pulled towards this beacon. The location estimation algorithm is given as follows:

$$a_w = \sum_{i=1}^{m} a_i w_i \,/\, \sum_{i=1}^{m} w_i \quad \text{....... (2)}$$

$$b_w = \sum_{i=1}^{m} b_i w_i \,/\, \sum_{i=1}^{m} w_i \quad \text{....... (3)}$$

$$w_i = \frac{1}{d_i^g} \quad \text{....... (4)}$$

Where, (a_w, b_w) is the estimated location, (a_i,b_i) is the location coordinate of i^{th} beacon, d_i is distance between tag and beacon i, and g is the degree of weight. Total number of beacons considered at any time for position estimation is denoted by m. The WCL positioning system is depicted in Figure.3.

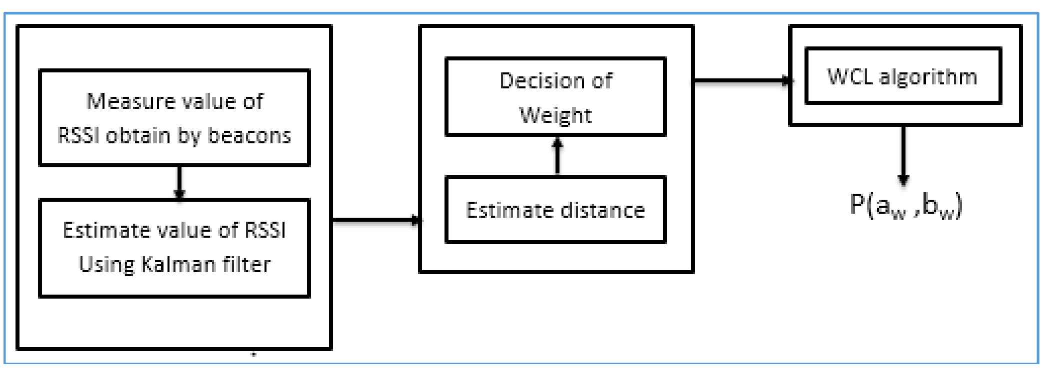

Figure.3: Operation procedure of WCL based positioning system, (a) data acquisition, (b) data processing, (c) location estimation

Since RSSI fluctuates over time due to attenuation and several noise factors, Kalman filter [18], is used on the top of moving average filter. The estimated RSSI is then converted to distance using the following formula:

$$P_r(d)[dBm] = A - 10n * \log_{10}(d) \qquad (5)$$

Finally, the selected beacons' locations and their respective estimated distances are used in WCL for position estimation. Here, beacons are selected on basis of their current RSSI values.

C. Proposed Model

As shown in Figure. 4 first user will enter the input by checking the availability of the internet. As the system receives the input it will immediately respond by showing the navigation directories. Now user will choose the direction and starts the camera, meanwhile system will start capturing the neighboring node signals and will calculate the RSSI value. Now by using RSSI value with WCL algorithm it will find the current location of the user. System will inform it to user and will display the further path to the particular building. User will use that indication and move further. User will ends and system gets terminated.

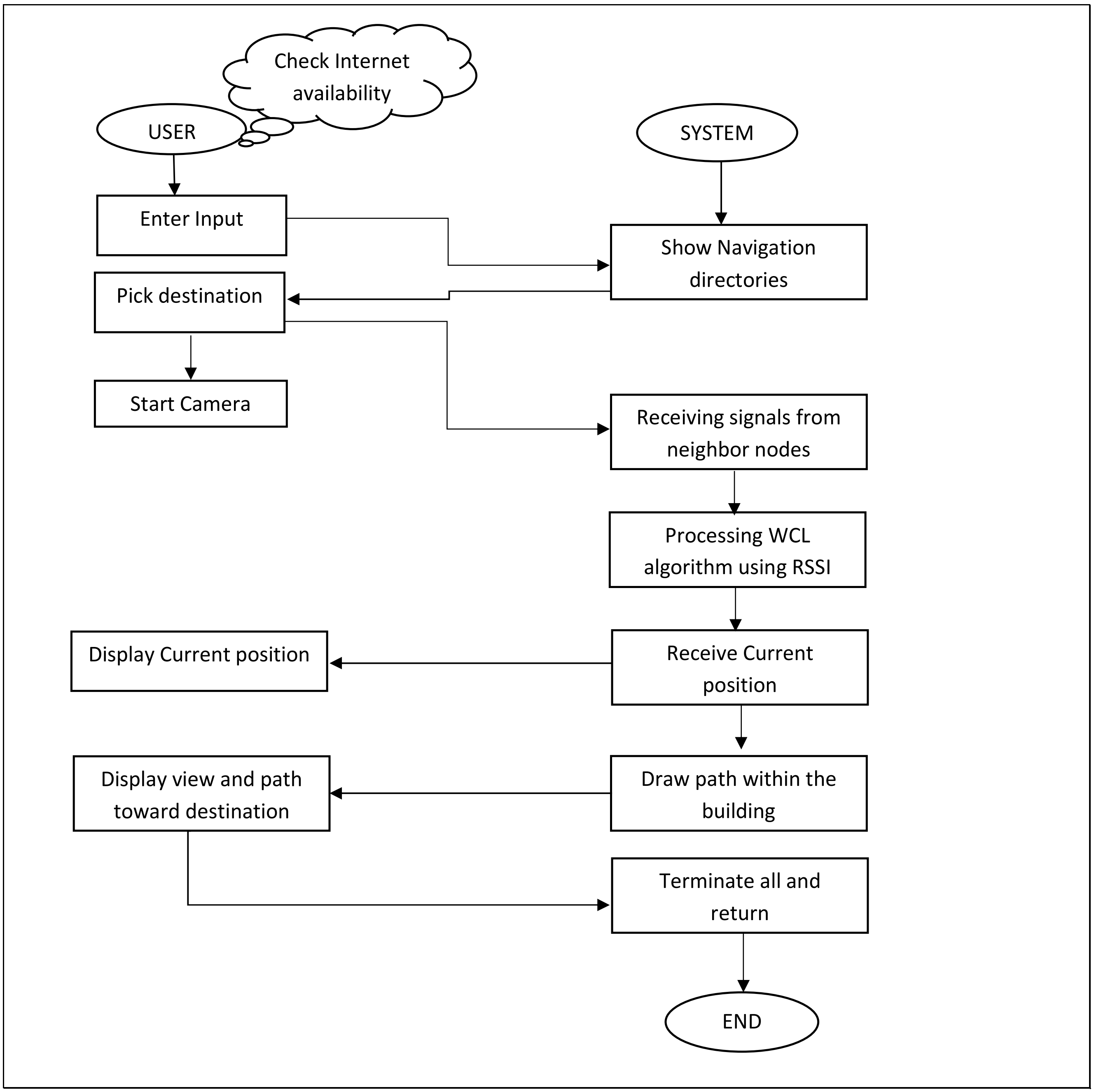

Figure 4. Proposed Model for indoor Navigation using RSSI value with Algorithm

IV. CONCLUDING REMARKS

From the view of various researchers the problem we conclude is the increase in error rates and response time beyond the limits. So we propose a method that by using a WCL algorithm with RSSI values obtained by Wireless signals can optimized the error rates by taking the differences among various anchor nodes and the client device. Through this we can also maintain the accuracy of the system.

V. FUTURE WORK

Further our task is to implement this improved algorithm by creating a different environment. We may use different hardware processor like Raspberry or Audrina or Node MCU with new efficient WCL Algorithm that capture the wireless signals to generate the RSSI values and to know the accurate current position of the client Device.

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