FUZZY CLUSTERING FOR IMPROVED POSITIONING

H. Kiwan and Y. Morgan

Software Systems Engineering, University of Regina

ABSTRACT

In this research, we focused on developing positioning system based on common short-range wireless. So we developed a system that assumes the existence of a number of fixed access points (5+) and employ arrival difference (TDOA) with Kalman filter. We also discuss multiple / tri-lateration and evaluate some of the root causes dilution of precision (DOP) positioning using Kalman Filter. This article presents a simpler approach fuzzy clustering (SFCA) to support the short-range positioning. We use fixed access points calibrated at 2.4 GHz. We use real time data observed in the application of our model offline. We have extended the model to mimic the signals communications (DSRC) 5.9 GHz dedicated short range, as defined in 1609.x. IEEE The results are compared in each case with respect to the metering plate need Differential Global Positioning System (DGPS) captured in the same test. We kept Line-of-Sight (LOS) in all our clear assessment and use of vehicles (<60 km / h) moving at low speed. Two different options for implementing the SFCA are presented, analysed and compared the two.

KEYWORDS:

RAP, DSRC, WiFi

1. INTRODUCTION

Since precise positioning using DGPS RTK can provide centimetre level accuracy only when the quality of the signal and the plural satellite signals are available. Urban canyons, tunnels, forests and construction sites are excellent examples congested environments DGPS RTK cannot work well. At least DGPS RTK requires four satellites with good geometry placement. In fact, many commercial systems often fail to resolve ambiguities of transport stage, unless (5+) satellites are present. Therefore, in order to maintain the level of accuracy in centimetres in such environments, a method for replacing and / or increased RTK DGPS signal is a necessary suboptimal condition. [1] 802.11 using street signs are proposed. Due to the wide availability of 802.11 signals in urban areas, we will focus on the availability of (5+) signs and centre the document in the position estimation model object using five 802.11 signals. While there are a limited number clustering algorithms in the initial number of groups are known before collation more known or computational algorithms complexity are, or can detect that the groups do not overlap, where the data points are closely clustered around a number of isolated centres. There are different approaches to strengthen the construction and analysis. One is the hierarchical approach, which divides all data supplied to two groups, then a partition of these two groups of two groups, and the partition continues until the desired number of groups or a certain criterion is met number is reached. While the hierarchical approach makes sense to group analysis, methods based on this approach [2][3][4] are complex calculations and are not a good choice for real-time applications.

Another approach is to direct single-level or split directly down to the desired number of data sets. Generally, the direct approach is simple enough so that the hierarchical computational approach. In this article, we present a clustering algorithm based on the direct approach with the

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number of known or assumed specified groups. The initial group consists ofSFCA algorithm and an iterative process based on a square criterion minimum average rating. SFCA be shown to converge faster compared with existing known methods [5], the performance and computational complexity. Since the selection of initial cluster centres often affects the results of clustering algorithms and the amount of calculation needed, an effective method for determining a reasonable set of initial cluster centres distributed based on component analysis is presented. Also note that our claim of faster convergence and effective initial cluster centre cannot be generalized because our assessment focuses on the application of main.Pendant positioning this time, the evolution of real-time applications require precise positioning vehicles (RAP) in conditions that are not favourable for GPS and the level of sub-centimetre accuracy. RAP has the fundamental solutions for precision fitting, Bus Rapid Transit (RBT), platoons, smart cars and other vehicle applications [6] [7]. In all these applications, the ability to accurately assess the results of objects in automated movements that save time and money. In the example of precision reception, manual hitch of a truck on a narrow shelf of time consuming and causes damage to the vehicle and the platform. Alternatively, automatic coupling can achieve an accuracy of <1 cm and runs faster than humans and a possible accuracy to be achieved by humans. In all these types of applications, RAP is essential to facilitate these applications [8] [9].Systems increase GPS satellite and always suffered dilution of precision (DOP) in adverse conditions where they blocked the satellite signals and low elevation angles tri-lateration distort the geometry diluted and the accuracy of the calculated position significantly. There have been several attempts to increase satellite solutions with other wireless signals, especially with the cellular signal as in [10] [11] and with broadband as in [12] [13]. Other researchers avoid altogether and built on road GPS markers, such as magnetic guidance systems as in [6] [8] [9] .Our research focuses on the use of high availability urban environment 802.11 signals. We discussed some of the factors behind short-range wireless DOP. We extend our solution to mimic the 5.9GHz dedicated short range communications (DSRC) and believe that the short-range nature enriches DSRC computing RAP follows: [14] [19]

a) DSRC uses high availability low latency (HALL) channel that can be utilized for positioning by utilizing round trip msg.
b) DSRC relies on Line-of-Sight (LoS) which would be available to all roaming vehicles.
c) The 5.9 GHz signal is strong and has relatively close proximity to roaming vehicles. The elevation angle and close proximity improve accuracy.

Furthermore, DSRC has been viewed as the natural communication media for VII and IntelliDrive initiatives. Therefore, we applied our scheme on both 802.11 and 5.9 GHz DSRC. [14][7]

Our proposed scheme apply extended Kalman filter (EKF) for the observed signal. The resultant is subjected to a simple observation from 802.11. Then, the problem becomes to investigate the accuracy varying from the actual observed data. Signals from different sources are grouped using the CFSP to provide reliable weight differentiated data available. The study illustrates the result of analysis accuracy and precious introduced a combined approach which has the potential to initiate new approach to advanced and complex. The rest of the paper is organized as follows; the second section provides information about propagation technique used channel is provided. Section three highlights the main convergence mechanisms of system aspects. The fourth section of the test environment and equipment used are described. Section Five evaluate and analyse the results. Section six concludes and discusses future work.

2. CHANNEL PROPAGATION MODEL

To clarify our ideas, suppose in an environment, objects are moving freely in any direction in space. At any point in time an accurate camera can capture the location of all objects as described in

Figure 1.a. If the same camera captures a second location of the moving objects, they could be at different locations as described in

Figure 1.b. Assuming that the camera is accurate enough that no movement happens during the limited time the picture was taken, then, at any given point in time each object is located in a unique position defined by three coordinates $\Lambda_i = (x_i, y_i, z_i)$ relative to a known absolute location. Also bear in mind that the selected set of coordinates could be angular, Cartesian, or any other coordinate system.

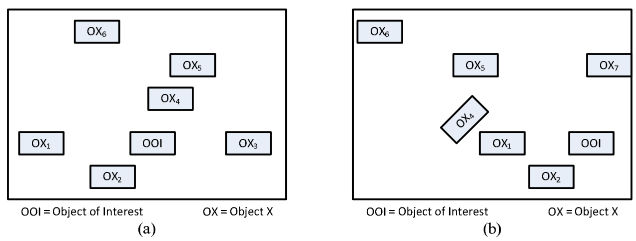

Figure 1:Mobile Environment with Random Motion

Now assume a wireless signal has N resolvable propagation paths between the transmitter and receiver. Since each reflector propagates multiple signals, and we potentially have multiple reflected signals, we shall select the strongest reflected signal. We also use the multipath signal parameters; Angle of Departure (AoD φ_i), Angle of Arrival (AoA θ_i), and delay of Arrival (DoA τ_i). All of (φ_i, θ_i, and τ_i) can be measured using any available technique with respect to common bearing direction. Then, as illustrated in

Figure 2, let (x_Λ, y_Λ), (x_o, y_o), and (x_i, y_i) be the true position of, respectively, the signal source, the object of interest, and the i^{th} reflective point where (x_o, y_o), and (x_i, y_i) are unknown. Let ρ'_i, ρ''_i be the lengths of the segments forming the i^{th} path respectively. Finally, let φ_i and θ_i be the angles of departure and arrival for the i^{th} path from the source to the object of interest.

From

Figure 2, we obtain φ_i and θ_i as a function of the locations of the mobile target and the reflection point.

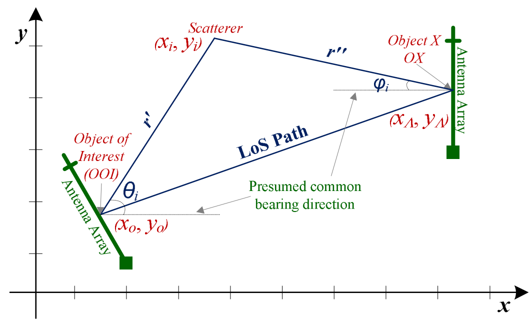

Figure 2: A Multi-path Propagation Channel Model

$$\begin{aligned} \theta_i(x_o, y_o, x_i, y_i) &= \arctan\left(\frac{y_i - y_o}{x_i - x_o}\right) \\ \varphi_i(x_o, y_o, x_i, y_i) &= \arctan\left(\frac{y_i - y_s}{x_i - x_s}\right) \end{aligned} \quad \ldots 1$$

Equation 1 applies for $i=1, \ldots, N$. Then assuming c is the, corrected, propagation speed, the Time Difference of Arrival (TDoA) can be determined by:

$$\tau_i(x_o, y_o, x_i, y_i) = \left(\frac{\rho_i - \rho_1}{c}\right) \quad \text{and } i = 2, \ldots, N \quad \ldots 2$$

Where $\rho_i = \rho'_i + \rho''_i$, and:

$$\begin{aligned} \rho'_i &= \sqrt{(x_i - x_o)^2 + (y_i - y_o)^2} \\ \rho''_i &= \sqrt{(x_i - x_s)^2 + (y_i - y_s)^2} \end{aligned} \quad \ldots 3$$

Since we need to obtain the unknown position (x_o, y_o) from the known position (x_A, y_A), given the uncertainty in ($\hat{\varphi}_i, \hat{\theta}_i$ and $\hat{\tau}_i$), we apply expected statistical error in measuring (φ_i, θ_i, and τ_i) such that:

$$\begin{aligned} \hat{\tau}_i &= \tau_i(x_o, y_o, x_i, y_i) + n_{\tau_i} \\ \hat{\theta}_i &= \theta_i(x_o, y_o, x_i, y_i) + n_{\theta_i} \\ \hat{\varphi}_i &= \varphi_i(x_o, y_o, x_i, y_i) + n_{\varphi_i} \end{aligned} \quad \ldots 4$$

where (n_{φ_i}, n_{θ_i}, and n_{τ_i}) are the statistical errors, $i=1, \ldots, N$ for $\hat{\varphi}_i$ and $\hat{\theta}_i$, but $i=2, \ldots, N$ $\hat{\tau}_i$.

Therefore, when the number of paths $N \geq 3$, we get ($3N-1$) measurements and ($2N+2$) unknown parameters. The problem yields a non-linear estimation problem that can be solved using machine learning or stochastic learning automata. In this article, we choose to solve it using later approach.

In that approach, all nodes cooperate to arrive to better relative ranging. Therefore, the collective behavior of the selected set of nodes, or a cluster, are guaranteed to converge, since the accumulation of relative distances will naturally tend to marginalize low accuracy ranging in favor of the multiplicity of better accuracy ranging. Further, since the boundaries of the selected set of nodes (a cluster of nodes) are finite, the problem lends itself to deterministic finite automata. In the following section, we discuss the formulation of the automata model.

3. SFCA Rate of Convergence

The performance rate of convergence of SFCA algorithms based on the criteria mentioned in Section 2.1, including the LMS criterion, depend upon the initial classification of the data set. [15]Proposed a procedure to find distributed initial cluster centers based on the comparison of the distances between various data points. However, their procedure requires a large amount of computation when the data size or the number of clusters is large enough like the case when clustering wireless signals. Now, we would like to present a simple method for generating initial cluster centers for the data set.

Assume that the p components of X are linearly independent and $p \leq$ N. Then, T is a positive definite and symmetric matrix and there exists a matrix C such that

$$CTC^t = D = \begin{bmatrix} d_1 & & & 0 \\ & d_2 & & \\ & & \ddots & \\ 0 & & & d_p \end{bmatrix} \quad 5$$

Whered_i: i=1, 2, …, p; are eigenvalues of T arranged in the order $d_1 \geq d_2 \geq \ldots \geq d_p$, and the row c_i of C is the eigenvector associated with the eigenvalue d_i. Now the distributed initial cluster centers can be found as follows:

Apply the orthogonal transformation C to the data set, i.e., $X \rightarrow Y = CX$ 6.

1) Based on the principal component analysis, and assuming that for i= 1, 2, …, p, the random variable $Y_{ki}= CX_k$. Letthe first R-1 components of Y_i, i = 1, 2,…, N, toform the corresponding vectors u_i of Y_i.

For each Y_i classify Y_i. with group θ_j if

$$\left\|u_i - \alpha_j\right\|^2 < \left\|u_i - \alpha_k\right\|^2, \quad k = 1,2,\cdots,R \ \& \ k \neq j \quad 7$$

2) Find the mean vector of Y_i's classified to individual groups in Step (3). These mean vectors are the initial cluster centers.

It is noted that, in case R-1 $>p$, the above procedure can still be used by employing generalized linear machines so that the number of components of the vector $\mathbf{X}$ is increased from p to q such that R-1 $\leq q$.

4. Testing Environment

To test the proposed approach, we implemented five points 802.11 access capabilities, but easily reconfigurable DSRC 5.9 GHz to imitate. The unit used Technocom multiband configurable network (MCNU) is illustrated in Figure 3. The units were implanted at the locations shown in Figure 4. The two test configurations were maintained over Innovation Drive (circular disc) and Goulbourn long way (a straight line to the left). In both cases, the MCNU units were replaced so that their signals are available through the observation path along Innovation Drive and then along the path Goulbourn.MCNU units and the exact distances between the units were calibrated using.We calculated laser measurement to an accuracy of <1 mm. The relative distances using laser measurements were validated carful and location of each MCNU was recorded. All MCNU was placed at a height of 1.75 m, which corresponds to the elevation of the antenna mounted on the vehicle. Used neutralized rise issues relevant to the line of sight and simplifies the problem in two dimensions as expected. The vehicle was driven at a speed of 20-40 kilometers per hour roaming.

Figure 3: Multiband Configurable Network Unit

The temperature during the test varies from + 5° to + 10° C. The temperature radio can heat slightly during the test. The average time to convert radios used in this condition was 200 ps and worst case performance of the oscillator is 20 ppm. The test was conducted in late May 2009. The software runs on PCs developed after collecting data from field observation. The system uses the extended Kalman filter (EKF) using 2.4 steps and then using the 5.9 GHz band. After two phase estimates are applied. First, the clock offset unknown receiver position, and only the difference between simple differential receivers' ambiguities. Secondly, the only difference estimators floating ambiguity estimator then differ with laser measurement (for precision laser measurement derived). This process is double difference ambiguity estimates.

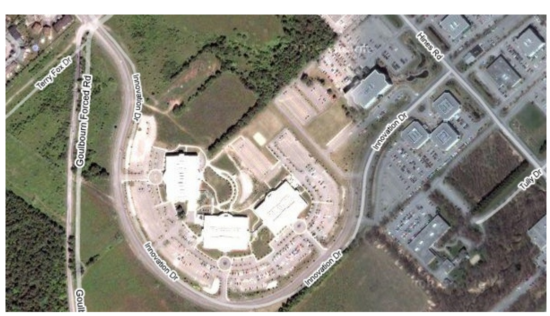

Figure 4: Satellite Image of Test Area

Object position using Kalman filter models as a random walk process with the right sound for dynamic limited operations, such as topography. We began to discuss the state of the shift clock receiver as a random walk. However, the error level was high enough to suggest an alternative approach. Reference UTC Therefore, we adopted synchronized already used by the DSRC 5.9 GHz and, therefore, the shift clock was based entirely on each update without filtration.

5. EVALUATION AND ANALYSIS

To benefit from the test conducted, corresponding to the time data was collected and observes the signal before and after the application of the Kalman filter. We conducted the test using the MCNU material that can be adjusted to simulate WLAN or DSRC. One interesting observation is the effect of the actual speed error rate as illustrated in Figure 5. The actual error here was normalized to neutralize the effect of the distance. The figure shows that the higher the vehicle speed is higher than the percentage of actual error. This arrangement resembles tests Goulbourn, when the vehicle operates in a nearly straight line. The trend shows greater error rate continued in all practice sessions, regardless of the use of the WiFi or DSRC. Also the relationship appears to be linear and constant in all our tests. The test results at very low speeds (<5 km / h) or relatively high speeds (> 55 km / h) have been marginalized in our test tools and environment have difficulty handling these speeds.

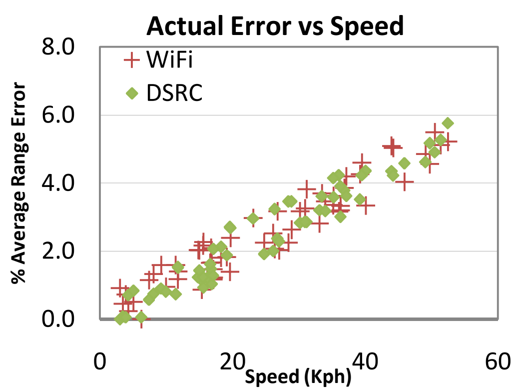

Figure 5: Speed vs Actual Error

In both the accuracy of upper and lower speed based on no closer wireless devices that showed better results. Figure 6 shows the absolute value of the estimated standard error in position against the fixed distance to the wireless device. The figure also shows results for different vehicle speeds. The straight lines expressing the WiFi test, while dotted lines express the DSRC test.

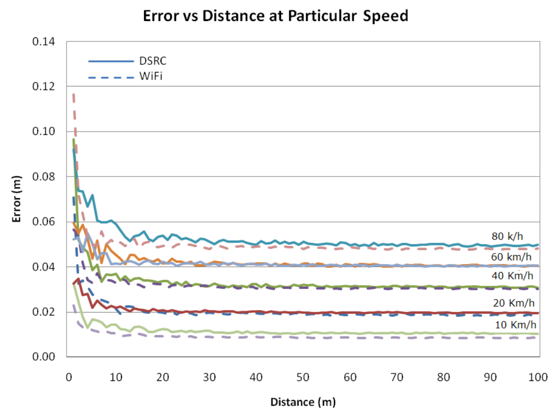

Figure 6: Error vs Distance at Particular Speed

Figure 6 shows that for a given speed, the absolute value of the standard error skip appear around the same value. The part of the curve that shows the distances of less than 5 meters in length cannot be used to draw conclusions about the very small distance can affect measurements. Figure 6 also shows that the use of 5.9 GHz DSRC means, in general, the smaller margin of error compared to using WiFi 2.4. This could be attributed to interference from 2.4 GHz band, in the area where the experiment was conducted with regard to interference in the band of 5.9 GHz. To confirm this observation, the average error is represented as a Depending on the distance measured, as shown in Figure 7. To simplify the drawing four test results were only used to draw the Figure 7, two Wi-Fi and two DSRC, the remaining results show the same trend. The figure shows the results more closely the use of points without slightest mistake wire.

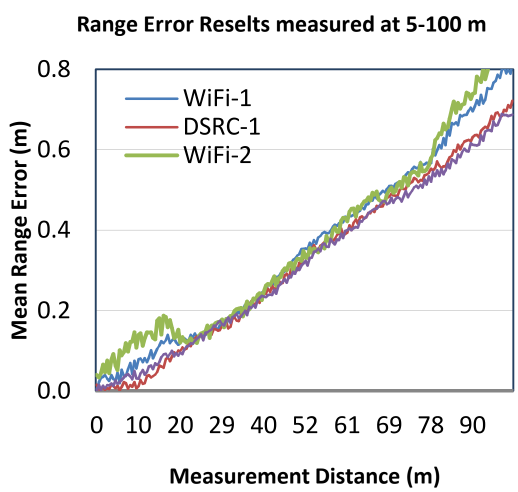

Figure 7: Mean Range Error vs Distance

The above results are also important to improve methods vary depending on short-range communications. Two important factors, namely, the speed and distance of vehicle have been shown to influence error. These two factors should have some influence. While it is difficult to identify the exact influence, the trend seems clear, higher speeds lead to greater errors. However, these results were obtained in an almost ideal environment Clear line of sight and in the presence of relatively fewer wireless noises. In addition, all tests were conducted road shows Goulbourn, a street almost straight. When replication test drive innovation (circular) Results showed relatively high levels of error. Therefore, a series of tests were performed to study the effect of relative rotation angle. The relative rotation angle is defined here as the angle between the directions of the vehicle at the time of observation in relation to the steering angle of the vehicle above five points. Figure 8 shows the error of relative rotation angles. The figure shows that, the larger the angle, the greater the likelihood of greater error. However, it is difficult to show a clear relationship.

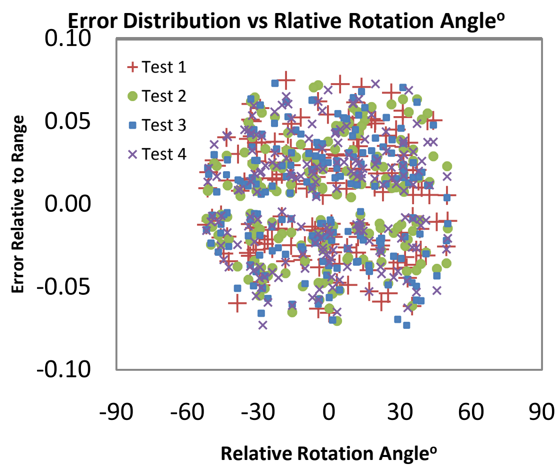

Figure 8: Ranging Error vs Relative Rotation Angle

This number confirms the findings of other studies using UWB where the angle of rotation tends to cause less dilution of precision. There have been efforts to include the angle of arrival (AOA) the use process. However, most previous attempts have focused on cellular signal; we intend to expand our work to include AoA as part of our ongoing investigations. [16][14]

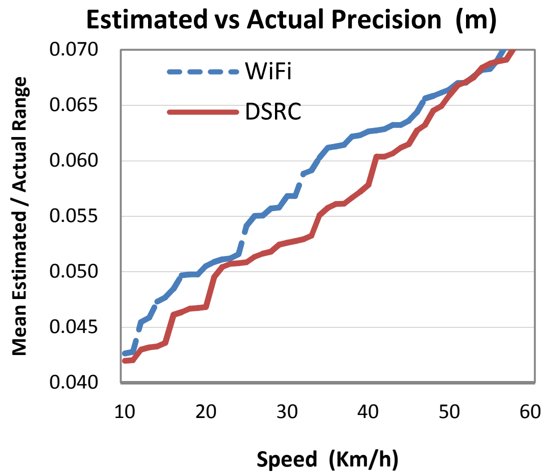

Figure 9: Overall Estimated Precision Errors

Positioning accuracy measured in our experiment was in line with our expectations. However, the observed accuracy remains below desired. Although the average positional error remains much higher than the level of 1 cm long, our results confirm the findings of other researchers as [12][17][13] wherein the use of UWB sends assessments We experienced the same average error here and illustrated in Figure 9. Figure 9 shows the average standard errors observed in all our trials and the vehicle speed is represented before. DSRC has always shown better results in low margins. In addition, the upward trend in the errors associated with increasing the distance varies continuously and can be seen in Figure 9.

6. Conclusion and Future Work

Although the results have met is encouraging, more work needs to be done to improve the accuracy and lower error rate. We are working on the following sources of error to mitigate the observed error and improve the performance of our technology. What follows is a description of some of the ongoing work to improve our system.

6.1 Threshold Detection Classifiers:

The receiver of granularity can be used to help a classifier time. The classifier time good electrical pulse signal received notes. In our application, the detection limit of the method for detecting we constant energy pulses and evaluated using the thin edge reducing the time. This classification shall be calibrated to draw the line carefully to avoid false detections due to noise peaks and keep the limit to the desired operation. This task can be automated and can be the subject of study itself.[18]

6.2 Geometric Walk Error:

Carefully calibrated limit of detection classifiers continue to suffer from foot geometric errors. [16] Defined geometric foot fault is caused by amplitude and pulse shape variations create geometric synchronization error gears. Jitter in time determines the accuracy in measuring the distance, a signal to noise function (SNR). Short Geometric is a major concern and can significantly dilute the accuracy precision. Albite no other known sources of error and the signal to noise ratio (SNR), signal availability, time and granularity other factors that will continue to influence accuracy. We firmly believe that we must remain focused on the small number of sources of error at a time, especially the error sources that can be neutralized in a controlled test environment. [14] [7] this research raised based on EKF and use multi-lateration and use of short-range communication such as Wi-Fi and DSRC. We have the availability of multiple signals (5+) along our experience. To the best of our knowledge, there has been no similar research in this area using the same wireless technology. Moreover, our accuracy corresponds to those obtained by the nearest wireless technologies such as UWB [13], which increases our confidence in the results and focus.

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