Journal of Physics: Conference Series

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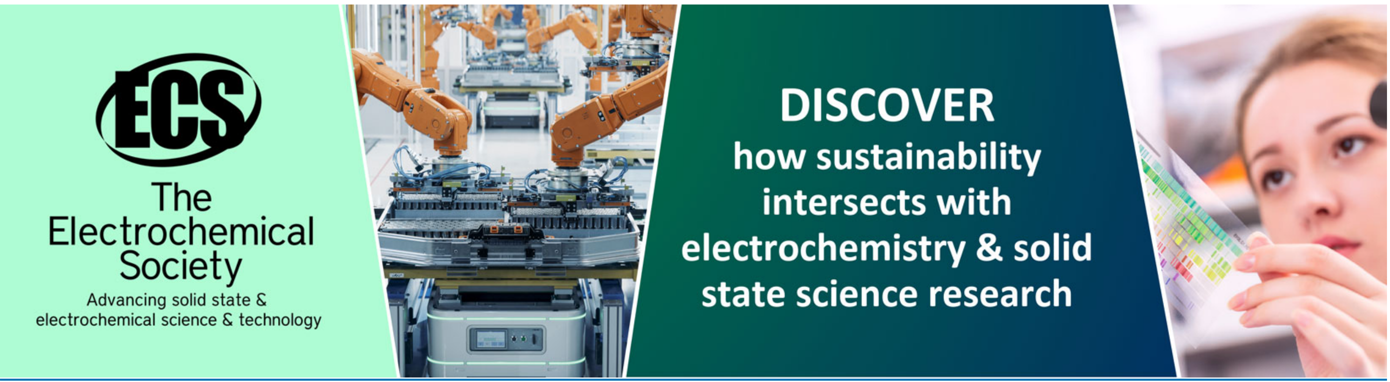
To cite this article: Dr. Haider Kadhim Hoomod and Sadeem Marouf M. Al-Chalabi 2018 *J. Phys.: Conf. Ser.* **1003** 012039





IOP Conf. Series: Journal of Physics: Conf. Series **1003** (2018) 012039 doi:10.1088/1742-6596/1003/1/012039

# Achieving Real-Time Tracking Mobile Wireless Sensors Using SE-KFA

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**Abstract.** Nowadays, Real-Time Achievement is very important in different fields, like: Auto transport control, some medical applications, celestial body tracking, controlling agent movements, detections and monitoring, etc. This can be tested by different kinds of detection devices, which named "sensors" as such as: infrared sensors, ultrasonic sensor, radars in general, laser light sensor, and so like. Ultrasonic Sensor is the most fundamental one and it has great impact and challenges comparing with others especially when navigating (as an agent). In this paper, concerning to the ultrasonic sensor, sensor(s) detecting and delimitation by themselves then navigate inside a limited area to estimating Real-Time using Speed Equation with Kalman Filter Algorithm as an intelligent estimation algorithm. Then trying to calculate the error comparing to the factual rate of tracking. This paper used Ultrasonic Sensor HC-SR04 with Arduino-UNO as Microcontroller.

## 1. INTRODUCTION

Arising to the progresses in mobile wireless devices and technologies, Real-Time (RT) be important with a development of necessities, e.g., system of movable agents in RT navigation systems. Various kinds of new applications needs to intend about the RT, which are putted in use to record the distances and tracking with some conditions of the entities in the surroundings. Each RT detections may be deals with a sensitive deadline on its termination time and it is necessary to meet these deadline conditions for safety or cost ( as an examples). Demands may be certified as lasting queries and govern in the system up to their deadlines have been expired. As an examples, a RT of a mobile agent may convince a navigation demand for the better way from its current location to its others destinations, surely the better trail will have to be permanency traced over RT until the agent get its destination[1, 2]. So, RT defined as an idiom used to distinguish system of computer that get the reaction at the same range as they trigged the order[3].

Choosing the mobile wireless sensor depending on the innate of the required projects. Some complexities appear when using mobile sensors because more of them are affected with material such as cotton, sponge, unshaped object[4]. Moreover, It could be impressed as well with humidity, wind, heat, interference waves, etc. [5].

In a pursuit of agent applications, the mobile sensors which can detect itself by itself as a target at a firmed time that kept in a lively mode while the others nodes in deactivate mode, so as to save power (energy) until the agent be near (or reach) the distinct desired points. To continuously observing mobile agent, multi sensors must be in active mode just before agent be close with them (the distinct desired points).

This tracking over RT calculations can be applied through various algorithms such: Kalman filter Algorithm (KFA), which is a well-known mathematical technique, KF is an predicator that estimate and correct the circumstance of wide range for linear processes as a future location of a mobile object, it

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could configured for single or multiple objects for tracking, unfortunately, with KF the object should move in static velocity or with constant acceleration. It is important to mention that KF algorithm consists two steps: prediction and correction (the update phase) by calculating the previous states for estimate the current state. The correction phase is uses the current state such as object location, speed to correct the status[6].

As a related works for this achievement, Multiple or single models which used tracking methods with estimation are provoke many researchers and institutions for estimate RT. Here are some synopsis of several studies and researches:

-Saptarshi Bandyopadhyay, et al. in 2016 IEEE conference, the Consensus Filter of Bayesian (BCF) used for monitoring and tracking the movements of a targets in RT according to a collective networks of multi-sensing agents. and by consensus achieved for the best predicate of the expected of the target's distributions states comparing with (LogOP), (BCF) algorithms and conditions on the communications networks topologies has been resolved[7].

-Philipp Kohler, et al, produced in 2013 an experimental for examined the use of cost-effectiveness, ultrasonic sensors widely used for the tracking vehicles especially with high velocities, However, the result take concerning about blind-spot-surveillance and lane-change decision systems is analyzed. the detection rate approach is delivered with RT calculations[8].

-Georges S. Aoude, et al in (2011), the researchers introduced an algorithm called RR-GP as a dilation of the closed-loop rapidly exploring random trees (CL-RRT) algorithm to calculate reachable blocks of movements for agent in RT. Furthermore, the concept showed a necessary achievements in a cost and accuracy[9].

-Boris Babenko, et al. wrote in 2009 that Multiple Instance Learning (MIL) tracers which unbind the confusion of agent appearance using multiple proposals of the agent and then improvably tracks the mobile agent with the online sundry instance learning algorithm. [10].

-H. He, et al. In 2008 (IEEE) had designed a range measurements tools using (S3C2410). The finesse improved using temperature indemnity module in RT[11].

-Y. Jang, et al. In 2007 (IEEE) had adopted a mobile walking distances measurements system which having 90% of perfection in RT[12].

-C. C. Chang, et al. In 2004 (IEEE) had searched the ultrasonic measurements systems for underwater operation. It uses ultrasonic kit, laser system beside a camera upon a system for 3-D location controls, it found the error rate equal to (±1) for each 35cm, but when added GIC filter working in RT, the error reduced to 0.6[13].

The remains of this paper, 2$^{ed}$ section mentioned around a criteria for selection an agent, 3$^{th}$ and 4$^{th}$ Parts are the specific details around the equipment and tools (Hardware / Software) which were used in a proposal system, 5$^{rd}$ section contain the proposed system, 6$^{th}$ part is the proposed system navigation, then 7$^{th}$ is the experimental results and discussion, the Penultimate part is for the conclusion and future works.

## 2. CRITERIA SELECTING A SUITABLE AGENT FOR REAL-TIME ACHIEVMENT

Many kinds of sensors can be found in the markets, it's an important to choose the suitable one, that mean the selection should impact some fundamentals criteria such: accuracy, range, distance, usability, cost and others[14].

like this proposal, a robotic model build to do a real test by placing sensor(s) up of movable robot, then make some processing to find the agent by itself and its locations (exact position) that can deal with a static known environment[15].

The concept's work for most of sensors is depending on the reflection of waves as in figure (1), the time duration that leaves the trigger pin until reflecting to the echo pin dividing by 2 should obtain the distance of that object (agent)[16, 17].

Meanwhile, with developments, different types of sensing technologies have been developed and examined to avert conflict among critical area of construction equipment[18]. However, in different environments, the performance of sensing technologies disparate, such as movable agents or with static objects. This variance appears many testing standards protocols to appraise the overall system performance and the pattern of objective which is looking for estimations to the next positions and RT.

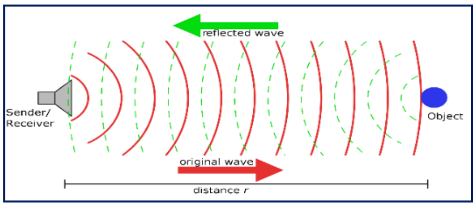


Figure 1. Concept Work of Sensor

Nevertheless, concerning to the exemplary caution when these kinds of sensors are used, RT could be impacted and achieved[19].

With scientific fields, normally sensor waves has different frequencies, the frequency range varies depending on the type for that subject. Figure (2) explain the concept of the interplaying between sensor and its environment[20].

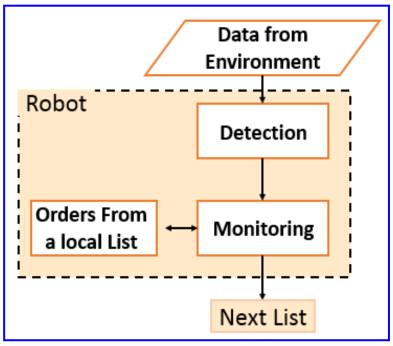


Figure 2. Concept Attractive Between Environment and Sensor

## 3. Hardware requirements

**A.** Ultrasonic Sensor (UsS): In this excrement, two HC-SR04 ultrasonic sensor has been chosen.

**B.** Arduino Microcontroller: Two (Microcontrollers) arduino UNO Board is used.

**C.** Transceiver Bluetooth: Two TB has been used, One of them connected with the automotive agent and the other connected to the computers, the data transmitted wirelessly between these two MC by two TcBT.

**D.** Steeper Motor (H-Bridge): Dual H Bridge- DC Drive L298N usually used for controlling motors speed and direction.

**E.** 4*4 Robotic Car: Four programmable DC-Motors, as a chase for picking up the whole kits for navigations.

## 4. Software Requirements

**A.** ARDUINO 1.5.6-r2: Using open-source arduino language for writing and uploading the arduino code, which named IDE Processing Language[21]. Additionally, the parameters can be monitored by the serial port online or offline by saving the result into a list (database).

**B.** VB.NET: Using VB.net environment for programing the algorithms for collecting all the results those needing for estimation RT.

## 5. The proposed system

Generally, monitoring and tracing some mobile wireless sensors (MWS) provoke the researchers and developers to concentrate on the mechanisms that tracking reliance to the RT. The proposed system looking for improvement and increasing the facilities on the agent navigation that traveling through static environment.

As related with these systems, surely the agent need a microcontroller(s) for controlling and guiding the robotic agent to do some coordination with the leader sensors. Then, Speed Equation - Kalman Filter Algorithms (SE-KFA) will used for achieving RT. and improved the efficiency as will appear in dissections section.

At the beginning, lets understand the whole algorithm which drown as a scheme in figure (3).

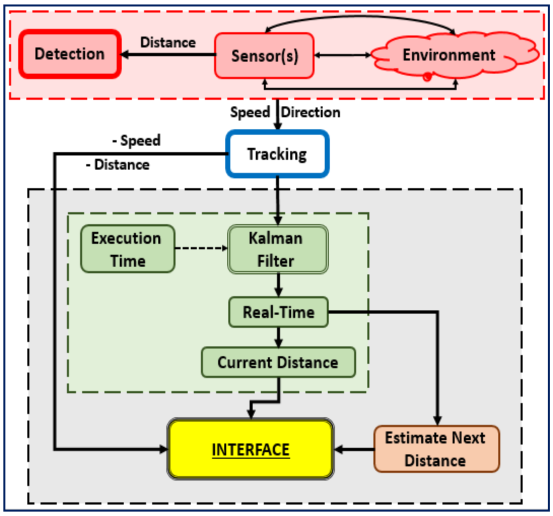


Figure 3. Scheme for Estimation Concept Work

**This scheme consist two main stages:**

1. The vision environment represented by the surrounded regions of the sensor(s) that could achieved the detection step. After detection step, the identifier step realized and the conditions for tracking has been achieved.

2. Second stage, represented by algorithms, the processed that accruing in the computer.

This proposal select a static / partially observed environment. When sensor turn on, the trigger sent its bullet and waiting for reflections while received by receiver pin (echo), certainly, this is controlled and calculated through microcontroller. By estimation, the total time travel dividing by two, distance can be obtained positively, these parameters achieved by mathematical speed in equation (1).

$$\boldsymbol{D = (T * V)/2} \tag{1}$$

*Where*: **D** = Distance, **T** = Time, **V** = Velocity

According to this tracking, distance (d) and time (T) has been collected. It is a good idea to mention that time (t) referring to the event at that distance, and distance (d) referring to the farness from the obstacle at this distinct point of time. Moreover, the distinct time that Microcontroller execution time for processing is ($t_{mc}$). Therefore, the input could be as in figure (4) below:

| | | |
|---|---|---|
| t | $t_{mc}$ | d |

Figure 4. Monitoring Controller Scheme

According to the equations of KFA, parameters (t, $t_{mc}$, d) treated in algorithm (1) below. Which explain the interactive between parameters obtained and SE-KFA until RT achieved:

***<u>ALGORITHM (1)</u>***

1. **Input:** i, dis , disTime, tmc, mct
2. exe[i] = tmc + mct

```
    t[i] = disTime
    d[i] = dis
    if ( i > 0 ) then
        Δt[i] = t[i] – t[i-1]
        Δd[i] = d[i-1] – d[i]
        if ( i = 1 ) then
            Tt[1] = 1
            Rte[1] = 0
            St[1] = Δt[i]
            NTE[1] = t[i] + St[1]
        else
            Tt[i] = 1 – (Δt[i-1] - Δt[i] )/( Δt[i] )
            Rte[i] = ( NET[i-1] – t[i] ) / t[i]
            St[i] = Δt[i] × ( Tt[i] – Rte[i] )
            NTE[i] = t[i] + St[i]
        End if
        S[i] = Δd[i] / St[i]
        array = SORT (s)
        If (count (array) mod 2 = 0 ) then
        x̃ = ( array( count(array) / 2 ) + array(( count( array ) / 2 ) + 1 )) / 2
        else
            x̃ = array( count(array) / 2)
        End if
        ES[i] = 2 × si[i] - x̃
        ENAL[i] = d[i] – ( ES[i] × St[i] )
        ETt[i] = exe[i] × ( Tt[i] – Rte[i] )
        EAL[i] = d[i] – ( S[i] * ETt[i] )
        Output: ENAL[i], EAL[i]
    End if
```

The algorithm above cleared that the time ($t_i$) and next distance ($d_{i+1}$) appear the predicates for the mobile agent reliance on the amounts of its previous experience by taking the amount of change over time ($\Delta t_i$) which resulting from subtracting the present time devoid of previous time ($t_{i-1}$), As well as, taking the change in distance ($\Delta d_i$) by subtracting the current distance from the previous distance ($d_{i-1}$).

To calculates the amount of new time variation ($\Delta t_{i+1}$), the variation amount of the next time disparity is require for calculations, for take in consecrations the challenges (side effectiveness) that affected sensor(s) while processes. The percentage of time taken ($T_t$)[1] is calculated by changing the current time variation ($\Delta t_i$) relative to the previous time variation ($\Delta t_{i-1}$), and this ratio is subtracted from 1 to obtain the percentage of time taken ($T_t$).

This procedure (the calculation of the amount of time variety) also depends on the amount of error ratio (RTe)[2], which also depends on the ratio of variety in the amount of next time estimation ($NTE_{i-1}$) relatively to the current time ($t_i$).

For calculating the supposed time ($St_i$) for that period which collecting from the multiplication of the amount of ($Tt_i$) with ($RTE_i$) insofar of current variety of time ($\Delta t_i$) which is used to calculate the current

[1] The initial value of ($T_t$) = 1

[2] The initial error ($RT_e$) = 0.0

speed and also if it associated with the variety in distance ($\Delta d_i$) and even to calculate the value of ($NTE_i$) if combined with the current time ($t_i$).

In order to estimate the next location of the agent ($ENAL_i$), speed estimation ($ES_{i+1}$) should calculate, which resulting from double value of current speed ($S_i$) subtracting from the arithmetic mean of the precioTuses velocities ($\hat{Y}_i$). When speed estimation achieved, ($ENAL_{i+1}$) can be reached successfully by subtracting the current distance ($D_i$) from the result of multiplied speed estimation ($ES_{i+1}$) multiplexing by time estimation ($St_i$). The algorithm processing can be represented as flow diagram in figure (5) below.

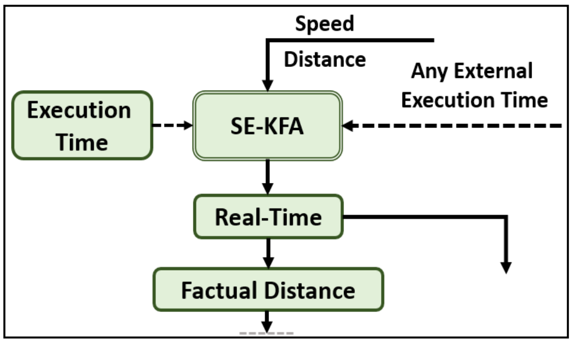


Figure 5. SE-KFA Processes

## 6. PROPOSED ESTIMATION ALGORITHM

Numerous kinds of experimental proposals has designed as a physical testing model, in this experimental, there are movable agent in the static environment. The navigation concepts are illustrated in figure (6):

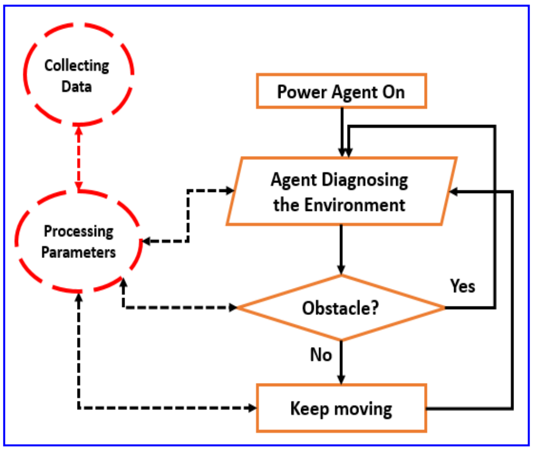


Figure 6. Flow Diagram for Navigation Concept

This navigation done by arduino, UsS and others tools (as above-mentioned in the requirement section) which controlling the whole operation. car robot (the agent) which can move forward, backward, left and right with different speeds and avoiding obstacles, this is depending on the algorithms that used for tracking. Figure (7) as a flowchart clarifying this roving algorithm. According to these general-purpose data, RT can be estimated. And calculate error deviation through Mean- Root Square deviation Equation (MRSD)[3]. And do mean testing by Standard Deviation (SD)[4]. For more information it is a good idea to see ref.[22].

[3] RMSD: used for measure differences between population values which predicted for an estimator and the values successfully observed.

[4] SD: is a criterion that used to determine the magnitude of variation or dispersal of a set of data values.

$$\boldsymbol{MRSD} = \sqrt{\frac{\sum_{t=1}^{n}(\hat{y}_i - y_i)^2}{n}} \tag{2}$$

*Where*: **yi** = depended variable, **ŷi** = predicted values for observation **i**, **n** = different predictions.

$$\boldsymbol{SD} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2} \tag{3}$$

*Where:* $x_1, x_2, x_3, \dots x_n$ = observed values, $\overline{x}$ = mean value, **N** = the size of the sample

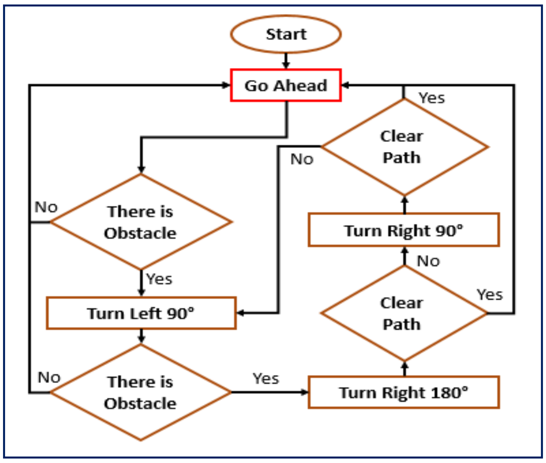


Figure 7. Flowchart for the Roving

## 7. RESULTS AND DISCUTION

The proposed technique has applied using VB.NET 2008 for test and calculate the RT estimation according to algorithm 1. IDE Processing Language V.1.8.4 for uploading the demanded code into the arduino MC for collecting parameters and controlling the agent that has been used. The computer specification was Corei5 with Ram 4G.

The experiments done three times for readings (25, 50 and 100) iterations in sequences, which implemented in static environment with (300*300cm). The initial distance started with 283.7cm and decreasing by (Δd) as an average according to the iterations that shown in table I.

Table I shown the excremental result for the time and distance error between the readings values and the estimations values, that measured using RMSD to calculate the differences between them, and SD to measure the quantify of the amount of variation for the set of mean square error between them.

The measured of RMSD with different iterations for the distance shown in figure (8, 9 and 10) and for the time shown in figure (11, 12 and 13).

**Table 1.** The Average Parameters for Delta-Distance by three deference sequences reading.

| Readings | Average Δd | RMSD t | SD t | RMSD d | SD d |
|---|---|---|---|---|---|
| 25 | 2.7876 | 0.139174 | 0.0922492 | 5.674394 | 4.28679 |
| 50 | 2.39586 | 0.103399 | 0.0730302 | 4.294559 | 3.26957 |
| 100 | 2.28603 | 0.080976 | 0.0559782 | 3.360349 | 2.56172 |

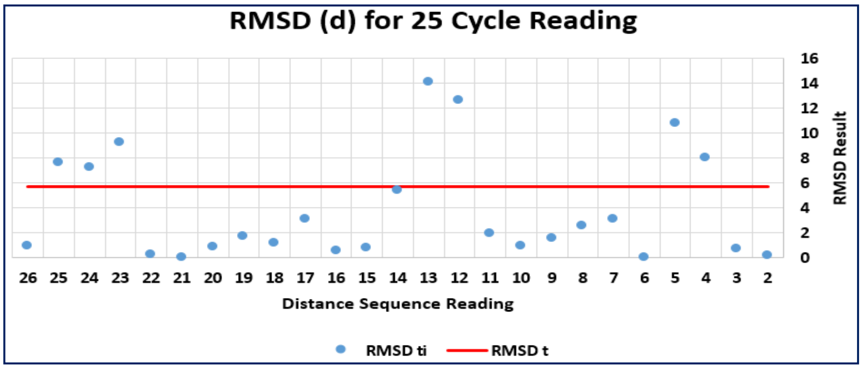


Figure 8. Error Rate for Mean over RMSD$_d$ for 25 Cyclic Readings

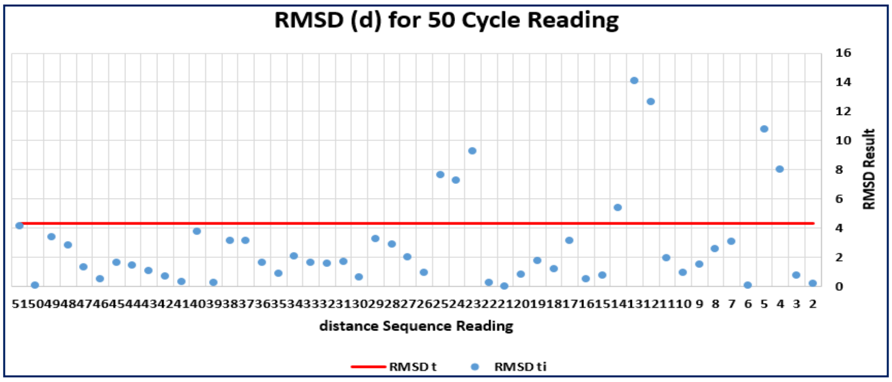


Figure 10. Error Rate for Mean over RMSD$_d$ for 50 Cyclic Reading

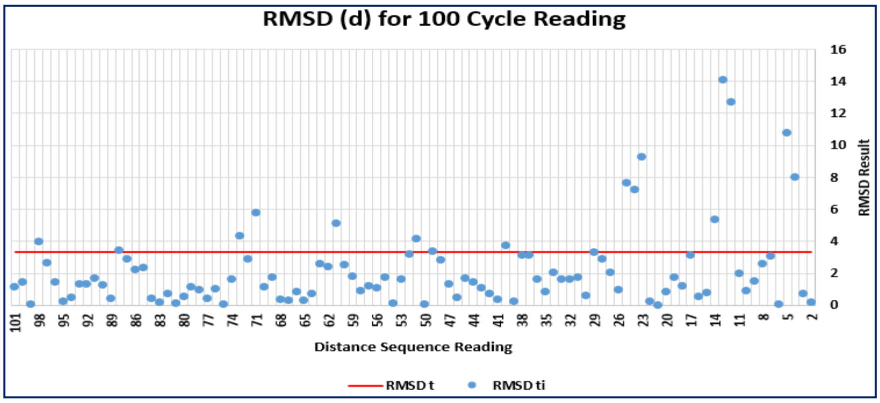


Figure 9. Error Rate for Mean over RMSD$_d$ for 100 Cyclic Reading

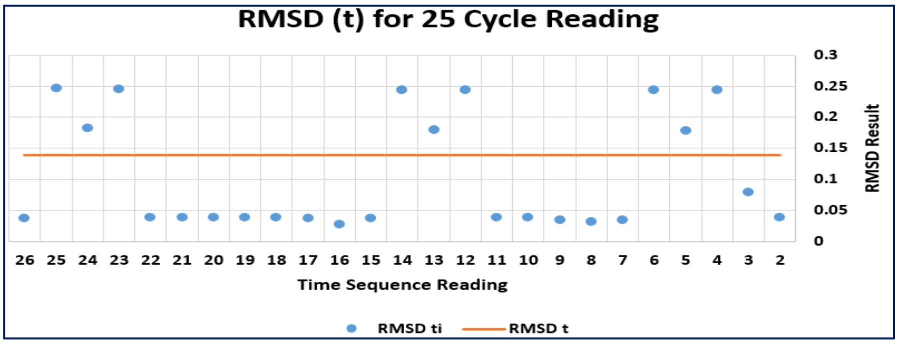


Figure 11. Error Rate for Mean over RMSD$_t$ for 25 Cyclic Reading

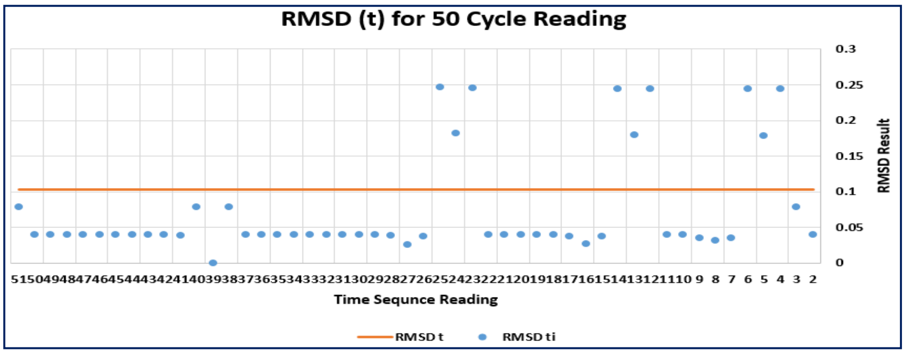


Figure 12. Error Rate for Mean over $RMSD_t$ for 50 Cyclic Reading

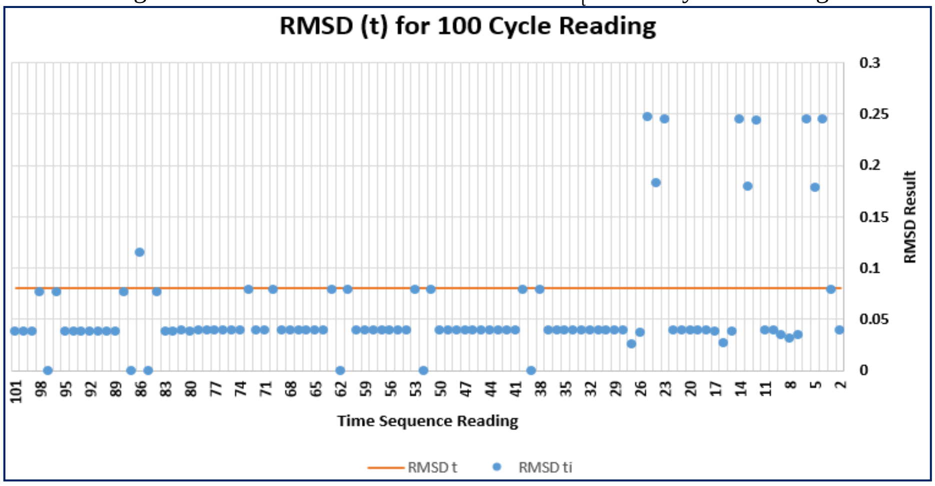


Figure 13. Error Rate for Mean over $RMSD_t$ for 100 Cyclic Reading

## 8. CONCILIATION AND FUTURE WORKS

In this paper, authors present an extensive study for tracking mobile wireless sensor to estimate Real-Time using SE-KFA. The errors between readings and estimations values for the time and distance measured using RMSD and SD with different iterations (25, 50 and 100). The experimental result shows that the RMSD value going to be closer to the stable state (sense to zero area) whenever collecting more readings as figure (14) which clarified these changeability. It is clear that when sensor did 25 readings (for both time and distance) the RMSD was 43%, 32% when 50 readings used, and finally 25% with 100 readings.

As future works, it could possible to use others types of sensors such laser sensor or any other perfect sensor for distance measurements to achieve RT and also could possible to test the impact of a curve movements with SE-KFA .

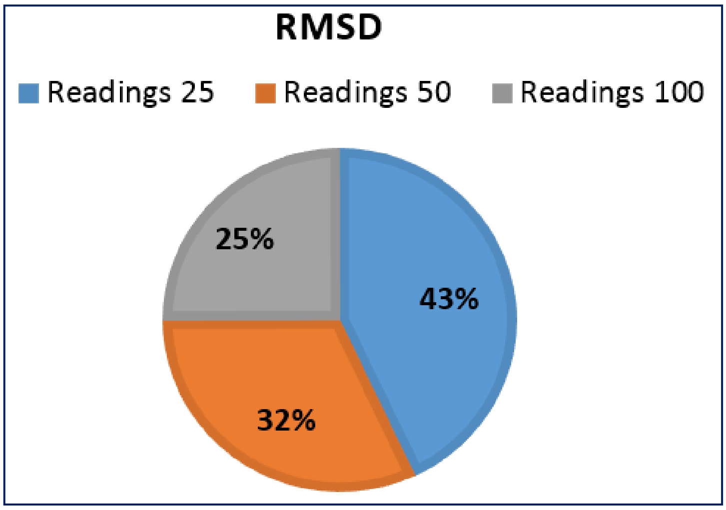


Figure 14. The Ratios for RMSD

## 9. References

[1] K.-Y. Lam, A. Kwan, and K. Ramamritham, "RTMonitor: Real-time data monitoring using mobile agent technologies," in *Proceedings of the 28th international conference on Very Large Data Bases*, 2002, pp. 1063-1066.

[2] G. S. Aoude, B. D. Luders, J. M. Joseph, N. Roy, and J. P. How, "Probabilistically safe motion planning to avoid dynamic obstacles with uncertain motion patterns," *Autonomous Robots*, vol. **35**, pp. 51-76, 2013.

[3] T. E. R. F. real-time. (n.d.). The American Heritage® New Dictionary of Cultural Literacy, 2017 from Dictionary.com, "*NDCL," T. AH, Ed.*, ed: USA Heritage, 2017.

[4] D. Marioli, C. Narduzzi, C. Offelli, D. Petri, E. Sardini, and A. Taroni, "Digital time-of-flight measurement for ultrasonic sensors," *IEEE Transactions on Instrumentation and Measurement*, vol. **41**, pp. 93-97, 1992.

[5] K. Ohtani and M. Baba, *Shape Recognition and Position Measurement of an Object Using an Ultrasonic Sensor Array*: INTECH Open Access Publisher, 2012.

[6] S. S. Pathan, A. Al-Hamadi, and B. Michaelis, "Intelligent feature-guided multi-object tracking using Kalman filter," in *Computer, Control and Communication, 2009. IC4 2009. 2nd International Conference on*, 2009, pp. 1-6.

[7] S. C. Bandyopadhyay, Soon-Jo, "Distributed estimation using bayesian consensus filtering," in *American Control Conference (ACC), 2016*, 2016, pp. 634-641.

[8] P. C. Kohler, Christian Verl, Alexander, "Vehicle tracking using ultrasonic sensors & joined particle weighting," in *Robotics and Automation (ICRA), 2013 IEEE International Conference on*, 2013, pp. 2900-2905.

[9] G. Aoude, J. Joseph, N. Roy, and J. How, "Mobile agent trajectory prediction using Bayesian nonparametric reachability trees," in *Infotech@ Aerospace 2011*, ed, 2011, p. 1512.

[10] B. Babenko, M.-H. Yang, and S. Belongie, "Visual tracking with online multiple instance learning," in *Computer Vision and Pattern Recognition, 2009. CVPR 2009. IEEE Conference on*, 2009, pp. 983-990.

[11] H. He and J. Liu, "The design of ultrasonic distance measurement system based on S3C2410," in *Intelligent Computation Technology and Automation (ICICTA), 2008 International Conference on*, Proceedings of the IEEE International Conference on Intelligent Computation Technology and Automation,Oct. 2008, pp. 44-47. , 2008, pp. 44-47.

[12] Y. Jang, S. Shin, J. W. Lee, and S. Kim, "A preliminary study for portable walking distance measurement system using ultrasonic sensors," in *2007 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Proceedings of the 29th Annual IEEE International Conference of the EMBS, France, Aug. 2007, pp. 5290-5293, 2007, pp. 5290-5293.

[13] C. C. Chang, C. Y. Chang, and Y. T. Cheng, "Distance measurement technology development at remotely teleoperated robotic manipulator system for underwater constructions," in *Underwater Technology, 2004. UT'04. 2004 International Symposium on*, 2004, pp. 333-338.

[14] M. Kelman, "Distance Measurement via Using of Ultrasonic Sensor," *Journal of Automation and Control*, vol. **3**, pp. 71-74, 2015 2015.

[15] Y. Golhar and U. Shrawankar, "Human Gesture Detection & Recognition: A Need of an Era," 2016.

[16] Y. Qi, C. B. Soh, E. Gunawan, K.-S. Low, and R. Thomas, "Assessment of foot trajectory for human gait phase detection using wireless ultrasonic sensor network," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. **24**, pp. 88-97, 2016.

[17] H. K. Hoomod and S. M. M. Al-Chalabi, "Objects Detection and Angles Effectiveness by Ultrasonic Sensors HC-SR04.", IJSR, Vol. **6** P. 6, 2017

[18] T. Guenther and A. Kroll, "Automated detection of compressed air leaks using a scanning ultrasonic sensor system," in *Sensors Applications Symposium (SAS), 2016 IEEE*, pp. 1-6.

[19] S. Choe, F. Leite, D. Seedah, and C. Caldas, "Evaluation of sensing technology for the prevention of backover accidents in construction work zones," *Journal of information technology in construction*, vol. **19**, pp. 1-19, January 2014 2014.

[20] D. S. Vidhya, M. D. P. Rebelo, M. C. J. DSilva, M. L. W. Fernandes, and M. C. J. Costa, "Obstacle Detection using Ultrasonic Sensors," vol. **2**, p. 316, APR 2016.

[21] A. DAusilio, "Arduino: A low-cost multipurpose lab equipment," *Behavior research methods*, vol. **44**, pp. 305-313, 2011.

[22] S. J. Finney, C. DiStefano, and J. P. Kopp, "Overview of estimation methods and preconditions for their application with structural equation modeling," in *Principles and Methods of Test Construction: Standards and Recent Advances* vol. **3**, ed, 2017.

**Acknowledgment**
Special thanks for MSc. Atheer M. Al-Chalabi for all his advises and supporting.