

Energy Efficient Target Tracking Method for Multi-Sensory scheduling in Wireless Sensor Networks

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Abstract: Data collection utilizing wireless sensors networks (WSNs) has been utilized for surveillance, monitoring environment, animal etc. Target tracking of maneuvering objects is an essential need of modern life. Nonetheless, because of diverse nature of sensor and complex environment, sensors measurement errors need to be minimized considering diverse motion states in process of tracking (sensing) operation. Enhancing network lifetime (i.e., reducing energy dissipation of sensor nodes) and improving tracking quality are major concern of target tracking using WSN. Form improving network energy efficiency, multi-sensory target tracking method has been modelled using Kalman Filter (KF) by existing target tracking method. The KF based model are affected due to presence of noise or missing data. For overcoming research issues this paper present an H-infinity filter (HF) to evaluate fusion for maneuvering target tracking in WSN. Further, to minimize the estimation errors and reduces/controlling the effects of outliers fuzzy H-infinity (FHF) filter for target tracking WSN is presented. Experiment outcome shows proposed HF and FHF fusion model attain better performance than existing KF based method for clustered based WSN in terms of positional and velocity root mean square error and energy dissipation.

Keywords: Energy efficiency, Fuzzy computing, H-infinity Filter, Kalman Filter, Network lifetime, Target tracking, Wireless sensor network.

I. INTRODUCTION

Wireless sensor networks (WSNs) emerge by the convergence of information and communication technologies (ICT) and by the coupling of sensor device (SD) which, due to technological advances, are becoming smaller, with larger processing capacity, lower energy consumption and costs. This gives rise to a leap on traditional techniques in the monitoring and control of activities of military, industrial and civil nature, among others [1]. A WSN can be defined as a set of sensor nodes in a network, which have characteristics and requirements that depend on the applications; in recent years, for environmental, vegetation or animal monitoring, in cases where human access is practically impossible or very expensive, as in the arctic regions, the use of wireless sensors has been chosen. These sensors typically have limited processing and memory, but they are usually small, they have low cost and energy consumption, long life time and they can be deployed to provide coverage detection in a certain area. Typically, it is necessary to charge these nodes periodically since they are battery powered. Therefore, network lifetime is considered as an important issue in

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WSNs. Tracking of moving object is an essential innovation in present day communication frameworks and incredibly adds to the non-military personnel applications [2]. The goal of the target tracking is to compute the states dependent on the noise observed by SD's. The way to its fruitful organization relies upon the successful and exact/precise collection of helpful data. Challenge and issues in tracking of directional objects/targets is because of dynamic and complicated tracking procedure such as, first, precisely identifying the moving objects state condition, (The tracking object is normally non-cooperative in nature. Along with, it might be hard to precisely depict the direction and speed of the object.). Second, managing with SD systemic error (SE) [3]. Along with, external impedance/interference, the estimation outcome collected from each SD, for example, pitch angle, azimuth point/angle, and distance include a specific measure of arbitrary error, which makes it even more hard to precisely assess the attributes of the moving object. These difficulties makes tracking of moving object an intriguing and problematic research area. As of late a few well-known approximation strategies have been presented for addressing tracking of moving object such as KF [4], nonlinear (NL) least squares (NLLS) [5], and extended KF (EKF) [6]. Since Kalman Filter is linear and unbiased in nature, it is a straightforward way of measuring the framework behavior. Along with, KF has least error variance (EV) of the unidentified state vector (SV), KF is utilized as an ideal recursive information computational design in wide range of applications and fields [7]. Nonetheless, because of the complex environment, unpredictable condition, and constraint of tracking method in practice, Kalman Filter is effectively influenced by generic noise, which prompts its dissimilarity if there should be an occurrence of Gaussian noise (GN). This is because the perception/observed condition of the moving object is normally nonlinear in nature, the Kalman Filter based method built for the ideal minimal-variance (i.e., least fluctuation) state estimation in linear discrete-time Gaussian models might not be appropriate. A few research work have merged discretization and linearization of respective stochastic frameworks by using the standard Kalman Filter method [10]. Well known Filter managing nonlinear frameworks incorporate extended KF, cubature KF (CKF), and unscented KF (UKF). The extended KF estimation method is viewed as the least difficult and sub-optimal (i.e., not perfect) however an effective state estimation model to deal with nonlinear frameworks. In recent times it's been utilized in scientific

and engineering aspect for quite a long time [8]. If there should arise an occurrence of frameworks with high nonlinear nature, the unscented KF estimation method is imperatives on GN and the practicality is generally very bad when contrasted with extended KF estimation method [9]. The core of the cubature KF is a circular spiral cubature rule. This aid it conceivable to numerically process multivariate time instance integrals of the NL Bayesian Filter (BF). While the cubature KF may give an efficient answer for high-dimensionality of nonlinear fusioning/filter issues, it is inadmissible for the target tracking application environment considering energy constraint of wireless sensor network. When the motion state of the maneuvering target and the detection environment are complex and lack information regarding the model or noise statistics, the target tracking problems are based on fuzzy set theory [10]. For example, after training fuzzy systems with KF and EKF, fuzzy Kalman filtering with Takagi-Sugeno rules coincides with discrete Kalman filtering equations. The validity domains of sensors are defined using fuzzy sets [11] while the KF and Takagi-Sugeno fuzzy modeling technique are combined to extend the classical Kalman linear state estimation to the nonlinear system. These methods have been widely used in applications such as dynamic mobile localization [12], truck backing-up problems [13], and trajectory tracking control [14]. Even though extended methods combined with fuzzy set theory, such as fuzzy KF or fuzzy EKF, are popular when dealing with target tracking problems, they have two main limitations: (1) the estimation of the motion states is important for tracking the maneuvering target during the entire tracking process because it directly impacts the parameters of the observation equation [15]. However, the existing methods estimate the motion states based on the speed and direction of the maneuvering target during a short period of time by using acceleration as a measure. This approach is imprecise due to a number of complex factors that impact the motion state, and (2) the error parameters in the tracking process are the systemic sensor's errors as the largest error contributors. These error parameters vary with motion states of the maneuvering target because there are multiple motion states during the tracking process. Since it would be inaccurate to adopt the systemic error parameters of the sensor to optimize the trace during the entire process, it is necessary to optimize them over a number of motion states during the tracking process.

For overcoming research challenges, this paper we are concentrating on the target tracking in some adverse practical conditions using fuzzy H-infinity in association with multitasking sensor networks. Fuzzy H-infinity helps to achieve effective maneuvering, fusion and Fuzzy Degree of Matching (FDM). Further, Kalman filter often produces noisy measurements and statistics, which can led to the performance degradation and inference problem. The fusion of two irreconcilable datasets is very difficult using Kalman filter. Therefore, to counter these drawbacks, here, we have replaced Kalman filter with an H-infinity filter to evaluate fusion and degree of matching parameters for maneuvering target tracking. H-infinity is an optimal control scheme to optimize and synthesize frequency which can be effective in any scenarios, even in worst case as it helps in reducing the

maximum errors and can easily eliminate the multivariable problems. H-infinity filter in association with data fusion and Fuzzy degree of matching can be very effective mechanism which increases system performance by reducing errors. Therefore, H-infinity filtering approach provides better results than the Kalman filter. However In some cases, we need a more effective technique which can provide precise results in unfavorable conditions. Therefore, this paper proposed here a new Fuzzy H-infinity filtering algorithm to get precise results. The key importance of this technique is that if two different sensors, consists of data loss then a combination of fuzzy H-infinity filter in association with data fusion can be used to reduce that data loss. Fuzzy H-infinity filtering algorithm helps in detecting and providing exact locations of moving objects. Fuzzy H-infinity filter can easily remove the white noise produced in the Kalman filter and produce Fuzzy H-infinity normalization (energy gain) to reduce the disturbances and ensures the better performance in terms of fusion and Fuzzy degree of matching. The important thing about the Fuzzy H-infinity is that it produces scalar factor which can be adjust according to the desired outcomes. This properties makes Fuzzy H-infinity filter a better choice upon Kalman filter as it reduces the errors consists in Kalman filter as well as provides properties to enhance the fusion and matching accuracy and increases performance of the target tracking.

The research contribution are described below

- Presented H-Infinity filter and Fuzzy H-infinity filter based target tracking method in wireless sensor network rather than KF. Thus, the proposed target tracking method is robust to noisy, missing measurement data and under complex environment.
- Presented target tracking method using cluster based wireless sensor network. Thus, aided in attaining better lifetime than existing target tracking method.
- The proposed model improved RMSE performance of multi-sensory data fusion process.
- Minimized energy consumption for tracking maneuvering target in wireless sensor network.

The manuscript is articulated as described: Section I, provide introduction of target tracking in wireless sensor network. Further, highlights research problem, issues and challenges in presenting efficient target tracking design in wireless sensor network. In section II, the proposed multi-sensory target tracking method using wireless sensor network. Experimental result and analysis is discussed in section III. Lastly, the conclusion with future research direction of work is discussed.

II. MULTI-SENSORY TARGET TRACKING METHOD IN WIRELESS SENSOR NETWORK

This section present an efficient multi-sensory target tracking method in wireless sensor network. Firstly, the system and energy model of multi-sensory target tracking in

wireless sensor network is described. Then, the proposed G-Infinity filter based multi-sensory fusion in wireless sensor network is discussed. Then, the Fuzzy H-Infinity model is described. Lastly, the error minimization using fuzzy degree of matching is presented.

A. System and energy consumption model

Let consider set of SD placed across environment in random and unequal manner for carrying out target tracking operation. Let consider for a given target tracking area R is deployed with N low power and low cost SD $S = \{s_1, s_2, \dots, s_N\}$. Every SD is composed of low-cost passive infrared and ultrasonic distance sensor which can sense target and can communicate with each other within its communication range defined. Further, this work consider the SD that sense same objects can communicate with other device by increasing the communication radius twice as sensing radius. Further, the sink/base station (BS) is placed at the edge of the network out of sensing range of SD. These base station collect data (i.e., target information) from nearest cluster head (CH). Then base station sent to remote server. As a result, the base station possess far greater communication range, and unlimited power than ordinary SD's. The location of SD and base station are known by each other during network deployment/initialization by using on-board GPS receiver. For easiness, the target tracking is modeled as a two-dimensional (2D) model.

Every SD in preliminarily initialized to sleep mode. When an object moves in a sensing area, some sensor along the curve path are woken up. Then, they estimate the distance among themselves and the object, and send the information to its cluster head. The cluster head again further sense the target and fuse his information with other sensor information collected. Then, it transmit to the remote base station. For saving energy and preserving tracking accuracy only few nodes are waken up. Energy consumption of target tracking is composed of sensing, information processing, and information transmission. However, most of energy is dissipated because of transmitting of the collected information. Let us assume the SD t_m is chosen as the task SD. The energy dissipation of SD t_m for object sensing and sensed information transmission is $E_{senTrns}$, depicted as a constant in this paper. For information transmission, the energy dissipated for transmitting k_{pkt} bits to a distance s_{mn} from SD t_m to SD t_n is described as follows

$$E_{trns}(m, n) = (e_{trns} + e_g s_{mn}^\theta) k_{pkt} \quad (1)$$

where e_{trns} and e_g are dependent on transmitter, and θ relies upon on the characteristics of channel and is considered to be time invariant (TI); the energy induced in receiving sensing information by SD t_m from its respective cluster head is described using following equation

$$E_s(m) = e_s k_{pkt}, \quad (2)$$

where e_s is dependent on receiving device t_n .

Hence, the overall energy dissipation of a cluster member (CM), t_m , at each time instance described using following equation

$$E_{Dissip}(m) = E_{trns}(m, C) + E_{senTrns} \quad (3)$$

Meanwhile, the overall energy induced of present cluster head described using following equation

$$E_{Dissip}(C) = E_s(C) \times O_l + E_{senTrns} + E_{trns}(C, B) + E_{trns}(C, C_o) \quad (4)$$

In equation (4), the first term on the right side describe the energy induced for receiving packet of present cluster head, which collect packet from both member SD and previous CH.; $E_{senTrns}$ is the energy dissipation for sensing, fusing, and transmission. In this paper it is considered to be a constant for all SD; $E_{trns}(C, B)$ is the energy dissipation from current cluster head to the closest BS; $E_{trns}(C, C_o)$ is the energy incurred for transmission of the object sensing estimation outcomes from the present cluster head toward future cluster head.

Therefore, the overall energy incurred at time-instance l is computed using following equation

$$E_{Tot} = \sum_{m \in \phi_l, m \neq C} E_{Dissip}(m) + E_{Dissip}(C) \quad (5)$$

B. H-infinity filter based multi-sensory data fusion in wireless sensory network

The H-infinity filter formulti-sensory data fusion applications is discussed in this section. Considering multiple sensor data, noise variance, miss acquisition and disturbances are inherit properties of a system. Under such circumstances that occur more often than not, H-infinity filter is robust and apt when compared to KF based systems currently in place. H-infinity filter considers Root Mean Square (RMS) signal/sensor data for filtering multi-sensory data fusion is achieved through H-infinity filter normalization techniques. The H-infinity filter discussed here is adopted for target tracking and is modelled using state space models. The state space models are defined as follows

$$x(k + 1) = Fx(k) + Gw(k), \quad (6)$$

$$y(k) = Hx(k) + v(k), \quad (7)$$

where x represents a state vector, F is a state transition matrix, G is process noise matrix, w is used to represent white Gaussian process noise with zero mean and covariance matrix Q . The sensor measurement vector is y , H is the sensor dynamic matrix and v is used to represent white Gaussian measurement noise with zero mean and covariance matrix R . The current state /scan number is k .

In existing Kalman filter based solutions, Gaussian noise of sensor measurements with knowledge of their statistical properties is assumed to be present. It is not the case in many systems where sensor measurement noise variations are random or of different types, here Kalman filter based solutions are rendered ineffective. High dimensional data handling capabilities are inefficient in case of Kalman filters. To overcome this drawback H-infinity filter are adopted. In H-infinity filter system is modelled using unknown deterministic noise of finite

energy [16]. The H-infinity filter is designed to ensure that energy gain / H-infinity filter normalization of unknown deterministic noise to tracking estimation error is lower than a predefined finite number γ . The ability of H-infinity filter to handle high dimensional sensor data (necessary for multi-sensory data fusion), non-deterministic noise variations, inaccurate system models and applicability to nonlinear systems render it as a robust filter for real time applications.

H-infinity filter is adopted to obtain estimates for every sensor $i \in m$ in multi-sensory data fusion [17], where m are the total number of sensors considered. Let x represent a vector, its estimation is represented using \hat{x}_i with covariance given as $P_i = cov(\hat{x}_i)$. Estimation error is represented using $\tilde{x}_i = \hat{x}_i - x$. Two matrices L_i and H_i are initialized and defined by unity matrix I [20]. Covariance time propagation of H-infinity filter for the i^{th} sensor is defined as,

$$\begin{aligned} P_i(k+1) &= FP_i(k)F' + GQG' \\ &\quad - FP_i(k)[H_i^t \quad L_i^t]R_i^{-1} \begin{bmatrix} H_i \\ L_i \end{bmatrix} P_i(k)F', \end{aligned} \quad (8)$$

Where

$$R_i = \begin{bmatrix} I & 0 \\ 0 & -\gamma^2 I \end{bmatrix} + \begin{bmatrix} H_i \\ L_i \end{bmatrix} P_i(k) \begin{bmatrix} H_i^t & L_i^t \end{bmatrix}. \quad (9)$$

H-infinity filter gain is computed as

$$K_i = P_i(k+1)H_i^t(I + H_iP_i(k+1)H_i^t)^{-1}. \quad (10)$$

Using K_i measurement update of state is computed as

$$\hat{x}_i(k+1) = F\hat{x}_i(k) + K_i(y_i(k+1) - H_iF\hat{x}_i(k)). \quad (11)$$

Multi-sensory data fusion using H-infinity filter local estimates (for $i = 1, 2$) is computed using

$$\begin{aligned} \hat{x}_f(k+1) &= \hat{x}_1(k+1) \\ &\quad + P_1(k) \\ &\quad + 1) \left(\hat{P}_1(k+1) + \hat{P}_2(k+1) \right)^{-1} \\ &\quad \times (\hat{x}_2(k+1) - \hat{x}_1(k+1)). \end{aligned} \quad (12)$$

Covariance propagation for multi-sensory data fusion using H-infinity filter is

$$\begin{aligned} \hat{P}_f(k+1) &= \hat{P}_1(k+1) \\ &\quad - \left(\hat{P}_1(k) \right. \\ &\quad + 1) \left(\hat{P}_1(k+1) \right. \\ &\quad + \hat{P}_2(k+1) \left. \right)^{-1} \hat{P}_1^t(k+1). \end{aligned} \quad (13)$$

In this paper authors adopt H-infinity filter for multi-sensory data fusion based tracking for non-linear systems i.e. maneuvering targets in wireless sensor network. Performance of H-infinity filter for multi-sensory data fusion based tracking evaluated using experiments discussed in further sections of the paper.

Performance of H-infinity filter degrades in presence of outliers proved in [18]. Performance of H-infinity filter can be improved if effects of outliers is controlled. To control performance degradation due to outliers and minimize

estimation errors H-infinity filter for multi-sensory data fusion is proposed in the next section.

C. Fuzzy H-infinity filter based multi-sensory data fusion in wireless sensory network

The H-infinity filtering algorithm is modified on the basis of filtering and fusion and modified filtering algorithm called as Fuzzy H-infinity algorithm. The procedures to evaluate weights $\hat{P}_1(k+1)$ and $\hat{P}_2(k+1)$ are similar to the H-infinity filter. However, some modification required to stabilize Fuzzy H-infinity filter. Eq.(15) represent the fused states of the fuzzy H-infinity filter. FIE (Fuzzy Inference Engine) is used to collect the descriptive information from the different sensors and classify that information. The final decision is taken by combining the decisions of classifiers.

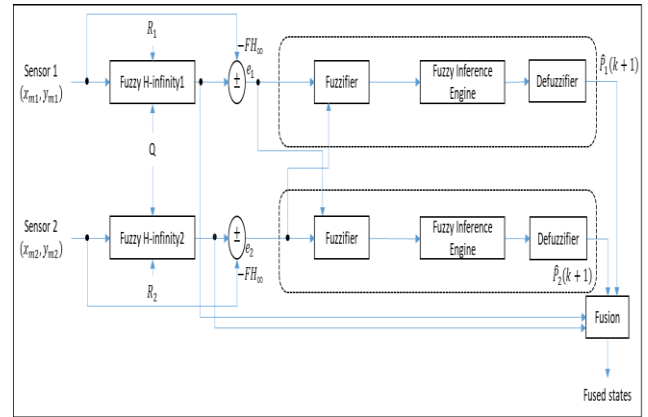


Fig. 1: Block diagram of proposed model for Fuzzy H-infinity.

The main advantage of fuzzy H-infinity technique is the simplicity of fuzzy technique. Fuzzy technique also involves accommodation of heuristic rules and relaxations of estimation process. The x and y components of innovation vector e extracted to track two dimensional targets e_x and e_y . It is estimated that the motion of target for each axis is independent. The fuzzy h-infinity innovation vector for x -axis is represented by,

$$\dot{e}_x = e_x(k+1/k) - e_x(k/k)/T \quad (14)$$

The high positive values of e_x and \dot{e}_x suggest that innovation sequence enhances at a very speedy rate.

D. Target state vector fusion model using H-infinity and Fuzzy H-infinity

The SVF (state-vector fusion) is a simplest process to combine the predicted states with state error covariance matrices achieved from fuzzy H-infinity and H-infinity. H-infinity filter's presence depends on the presence of conditions in [19]. The state vector and covariance are fused together to predict state vectors and covariance matrices of every sensor. The H-infinity fusion estimates can be expressed as:

$$\begin{aligned} \hat{x}_f(k+1) &= \hat{x}_1(k+1) \\ &\quad + P_1(k) \\ &\quad + 1) \left(\hat{P}_1(k+1) + \hat{P}_2(k+1) \right)^{-1} \\ &\quad \times (\hat{x}_2(k+1) - \hat{x}_1(k+1)). \end{aligned} \quad (15)$$

$$\begin{aligned} \hat{P}_f(k+1) &= \hat{P}_1(k+1) \\ &- \hat{P}_1(k) \\ &+ 1) \left(\hat{P}_1(k+1) + \hat{P}_2(k+1) \right)^{-1} \\ &\times \hat{P}_1^t(k+1) \end{aligned} \quad (16)$$

State Fusion and covariance in time propagation is,

$$\tilde{x}_f(k+1) = F\tilde{x}_f(k) \quad (17)$$

$$\tilde{P}_f(k+1) = F\tilde{P}_f(k)F' + GQG' \quad (18)$$

State transition matrix is represented by,

$$F = \begin{bmatrix} 1 & T & \frac{T^2}{2} \\ 0 & 1 & T \\ 0 & 0 & 1 \end{bmatrix} \quad (19)$$

Noise gain matrix is represented by,

$$G = \begin{bmatrix} \frac{T^3}{6} & \frac{T^2}{2} & T \end{bmatrix} \quad (20)$$

State Fusion and Covariance measurement update expressed as:

$$\begin{aligned} \hat{P}_f^{-1}(k+1) &= \tilde{P}_f^{-1}(k+1) \\ &+ \sum_{i=1}^m \hat{P}_i^{-1}(k+1) - \tilde{P}_f^{-1}(k+1) \\ &+ m - 1/\gamma^2 L_t L \end{aligned} \quad (21)$$

E. Error minimization using fuzzy degree of matching

Fuzzy H-infinity filter in association with data fusion and Fuzzy Degree of Matching can be very effective mechanism which increases system performance by reducing errors. Here, Q supposed to be known to get tuning of covariance matrix. If the value of covariance matrix is less, then the measurement is more precise and if it is more, then it became inaccurate. In those cases, this work focus more on estimation rather than measurement in H-infinity filter. Therefore, the covariance of the optimization can be presented as,

$$S(k) = F\hat{P}_i(k)F' + GQG' \quad (22)$$

$$\hat{S}(k) = 1/Nw \sum_{k=i-Nw+1}^i e(k)e^T(k) \quad (23)$$

The sample optimized covariance can be evaluated using average moving window. The size of the window selected as to get satisfactory smoothness. To get difference between the sizes of windows, we use degree of matching parameter, which can be defined as,

$$DOM(k) = S(k) - \hat{S}(k) \quad (24)$$

To get R values degree of matching parameter is used by fuzzy inference system (FIS) using Mamdani model. Eq. (22) with increase in Q , the covariance of optimization S also increases. Therefore the degree of matching \mathbb{D} value depends on the Q .

Rule 1: If $\mathbb{D}(k) \cong 0$, $S(k)$ and $\hat{S}(k)$ are nearly equal, then maintain covariance matrix at the same value and matches perfectly.

Rule 2: If $\mathbb{D}(k) > 0$, means that $S(k) > \hat{S}(k)$, then covariance matrix decreases

Rule 3: If $\mathbb{D}(k) < 0$, means that $S(k) < \hat{S}(k)$, then covariance matrix increases

If $\mathbb{D}(k)$ near to zero that indicates $S(k)$ and $\hat{S}(k)$ are matching perfectly. Then no change required. If $\mathbb{D}(k)$ is greater than zero the theoretical value $S(k)$ is higher than the actual value $\hat{S}(k)$ then adjustment is needed. Moreover, If actual value $\hat{S}(k)$ is higher than the theoretical value $S(k)$. Then also adjustment needed.

Correction factor $\Delta Q(k)$, can be considered to create tuning of Q using FIS. This $\Delta Q(k)$ factor, can be added or subtracted from the diagonal elements of Q matrix at every instance.

$$Q(k) = Q(k-1) + \Delta Q(k) \quad (25)$$

The proposed H-Infinity and fuzzy H-infinity filter attain better target tracking performance when compared with existing model which is experimentally proved below.

III. EXPERIMENTAL RESULT AND ANALYSIS

The proposed H-infinity filter and Fuzzy H-infinity filter is developed using Matlab. Performance of H-infinity filter and Fuzzy H-infinity filter is compared with existing filter method [9] for maneuvering target tracking in wireless sensor network. The sensor network size is fixed with 1000m*1000m with 100 sensor nodes. Further, it composed of 10 cluster head nodes where each cluster head nodes has 10 member nodes. The base station/sink is placed outside the sensing region of WSN. In this simulation study target maneuvering model described by Eq. (6) and Eq. (7) is used to generate the simulated data similar to [10]. State vector x consists of target position, velocity, and acceleration data. Simulation time of 250 seconds is considered. Sampling time $T = 0.25$ seconds is considered. Hence a total of 1000 scans are obtained in this simulation. Sensor measurement noise with $\sigma = 10$ is considered. Simulations are carried out using Kalman Filter based method namely MSJPDA (multi-sensor joint probabilistic data association), Fuzzy H-Infinity Filter and H-Infinity Filter. Target estimation results obtained using all filters are stored and error matrices are computed in terms of root mean square (RMSE) [10]. The RMSE is computed using following equation

$$RMSE(k) = \frac{1}{\sqrt{M}} \sqrt{\sum_{i=1}^M [p_t^i(k)]^2} \quad (25)$$

where M depicts the Monte Carlo iteration size, $p_t^i(k)$ depicts positional error of target t at instance k .

A. Target tracking of objects using H-Infinity and Fuzzy H-infinity

This section evaluate target tracking performance attained by proposed H-infinity, Fuzzy H-infinity Filter over existing method. The target tracking performance is evaluated in term of RMSE using Eq. (25). In Fig. 1, and 2, the x-axis depicts time and y axis depicts the RMSE value in meters. From Fig. 2, Fig. 3 and Fig. 4 it can be seen, the proposed H-Infinity model attain better RMSE performance when compared with existing MSJFDA. Further, the proposed H-infinity method attain a minimum RMSE of 0.156 and maximum RMSE of 0.429. Similarly, the proposed Fuzzy H-infinity method attain a minimum RMSE of 0.146 and maximum RMSE of 0.403. On the other side the existing method attain minimum RMSE of 0.438 and maximum RMSE of 0.7135. Thus, the proposed H-infinity and Fuzzy H-infinity model is much more efficient than existing method in terms of RMSE minimization for target tracking in wireless sensor network. The adoption of Fuzzy rules in target tracking using H-infinity filter aided in further minimizing the target tracking error when compared with H-infinity filter without fuzzy.

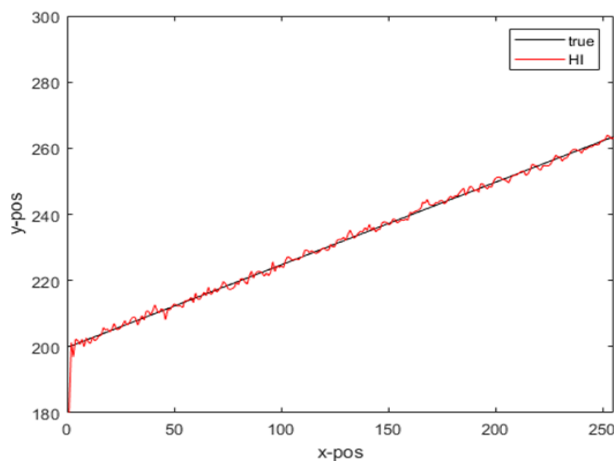


Fig. 2: RMSE performance of using proposed H-Infinity (HI) Filter for target tracking in wireless sensor network.

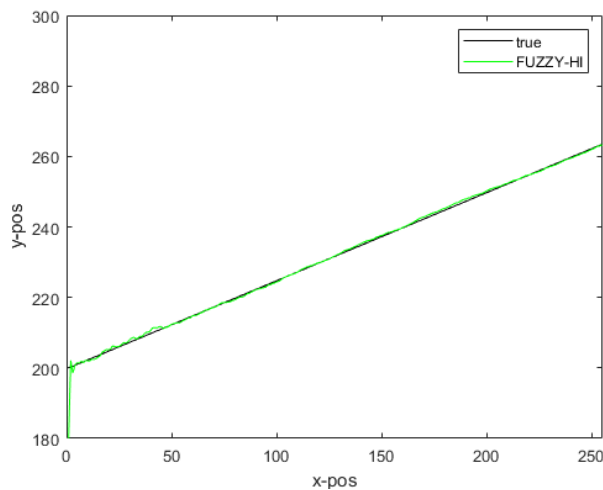


Fig. 3: RMSE performance of using proposed Fuzzy H-Infinity (HI) Filter for target tracking in wireless sensor network.

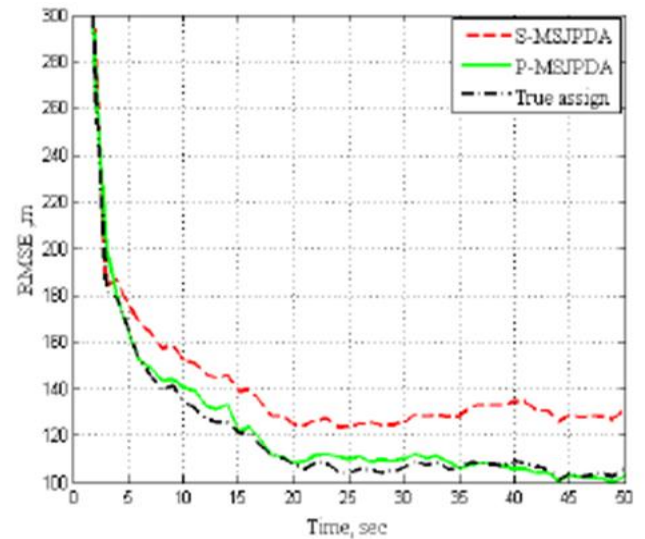


Fig. 4: RMSE performance of using existing MSJFDA Filter for target tracking in wireless sensor network.

B. Energy efficiency performance evaluation of Target tracking in wsn using H-Infinity and Fuzzy H-infinity filter.

This section evaluate target tracking energy efficiency performance attained by proposed H-infinity, Fuzzy H-infinity Filter over existing KF based target tracking method [1], [9]. The total energy consumption/Dissipation is computed using Eq. (5) as shown in Fig. 5. The existing target tracking method did not considered energy evaluation. The energy dissipation using H-infinity filter is 48.3036 J, 64.4421 J, 80.5014 J, and 93.5031 J for 500, 1000, 2000, and 5000 scans, respectively. An average energy dissipation ratio of 0.055 joules per scan is achieved by proposed H-Infinity target tracking method. The energy dissipation using Fuzzy H-infinity filter is 45.471 J, 60.478 J, 75.57 J, and 87.5644 J for 500, 1000, 2000, and 5000 scans, respectively. An average energy dissipation ratio of 0.0516 joules per scan is achieved by proposed Fuzzy H-Infinity target tracking method. An average of 6% reduction of energy is consumed by Fuzzy H-infinity filter over H-infinity filter based target tracking method in WSN. The significant result attained is due to adoption of cluster based wireless sensor network for target tracking. The overall result attained shows the proposed target tracking method is robust in terms of RMSE and energy dissipation minimization considering varied scan size when compared with existing method [1], [9].

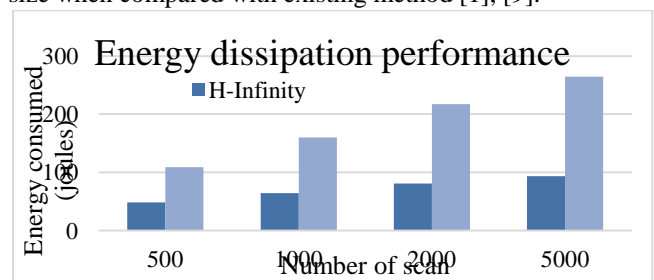


Fig. 5: Energy dissipation performance attained by H-Infinity and Fuzzy H-infinity.

IV. CONCLUSION

The significance and complexities in designing real time multisensory data fusion based target tracking in wireless sensor network is discussed. Drawbacks of current systems in place adopting Kalman Filter and its variants is presented. Presented an H-Infinity and Fuzzy-Infinity based filter for non-linear maneuvering target tracking in WSN. The H-Infinity model presented aided in reducing positional error of target tracking. Further, using Fuzzy H-Infinity every SD can remove local estimation errors within filter level. Further, using additional fuzzy logic system we can remove negative effect of outlier and estimation error at fusion level. Then, using covariance matching the model can remove filter divergence in presence of uncertainties and attain robust target tracking performance. The Fuzzy H-Infinity filter can adaptively be optimized utilizing fuzzy logic based degree of matching observed. Further, using cluster based network significantly aided in reducing energy dissipation of wireless sensor network. Experiment outcome shows the proposed H-infinity based tracking method attain an average RMSE of 0.372, Proposed Fuzzy H-infinity based tracking method attain an average RMSE of 0.352, and existing tracking method attain an average RMSE of 0.365. Results presented considering RMSE proves that H-infinity filter and Fuzzy H-infinity tracking method exhibits better performance than MSJPDA. Further, the adoption of cluster based WSN aided in attaining an average energy dissipation ratio of 0.055, 0.0516 joules per scan by proposed H-Infinity and Fuzzy H-infinity target tracking method, respectively. Future work would consider evaluating proposed model over fuzzy based KF tracking method. Along with, consider evaluating under complex target maneuvering and noisy environment.

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