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Robust Object Tracking using Data Fusion

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Abstract

Attempt has been made to fuse data from multimodal sources in this work for the purpose of object tracking using Kalman Filter. Two sources used for data collection are namely visual data from camera and vibration data from accelerometers. It has been observed that by using multimodal approach, better accuracy is achieved in occlusion handling.

Keywords: Data fusion, Kalman Filter, Object Tracking.

I INTRODUCTION:

Authors get their motivation from the tracking problem solving procedures used by humans, animal or birds in their day to day life. Examples include use of different sensors such as light and sound for tracking and identifying the moving objects by humans and animals. Ultrasonic wave and visual data fusion by some species such as bats. Infrared and visual light fusion by some species of snakes etc. Examples are many and quoting all is out of scope of this text. It can be agreed upon without much debate that if two or more senses are used for the purpose of tracking, we can arrive at conclusion much faster even in adverse conditions, Such as low light, occlusion, shape deformation coupled and color change[1][2][3][4][5].

Occlusion can be of many types. Self-occlusion, occlusion from other bodies present in the frame. When the body under consideration is being occluded by other objects in the frame, then it is intuitive to use the other properties possessed by the body under consideration.[6][7][8][9]

Therefore the problem gets transformed to combining data from different sources regardless of their modality and use it synchronously. It can be assumed that there are N separate sensors with their different measurement dynamics and noise characteristics. A joint matrix indicating the current state of the system is needed to be obtained. Which is better than a similar matrix produced by single sensor system. There are many techniques and algorithms used and proposed in literature for data fusion but Kalman filter has been used in this work for the simplicity it proposes.

It has been found that Vibration signals on road surface are less susceptible to interfering noise, this property can be used optimally for detection of vehicles. Also the signal obtained from vehicle interaction with road surface is having narrow bandwidth which make processing efficiency and speed higher. Much effort and research has been taken upon by scientific community in taking up visual object tracking using cameras. It is still considered to be unsolved and open problem in machine or robotic vision.

Attempt is made to use both the seismic and visual data fused by Kalman Filter for the purpose of Object Tracking.

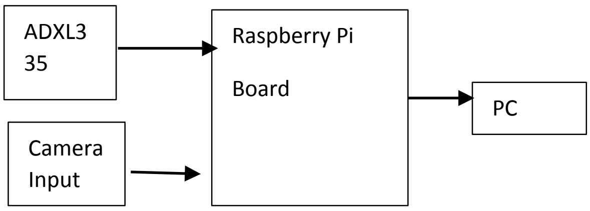
Kalman filter contains two individual steps, the prediction step and the measurement step. Both steps are combined and operated in a recursive routine to realize optimal Kalman filtering process. Another exceptionality of Kalman filter is the assimilation of prediction errors and measurement errors into the overall Kalman filtering process. Each prediction and measurement process consists of errors in random nature. These errors or “noise” are defined using the stochastic process. A real- time application can be demarcated as an application or program that reacts or responses within a predefined time frame, where such predefined time frame is a enumerated time using a corporeal clock [10]. From a real- time application's the real world's continuous time is turned into discrete time frame. Different real- time applications have different discrete time steps, which in turn defined the response time of the applications. The real- time application must react within the predefined time frame to provide latest response. Such real- time restrictions force the application to complete its routine within the time frame, else the output may not be accurately reflecting the current state of input.

Currently there exist two commonly used measurement fusion methods for Kalman-filter-based multisensor data fusion. The first (Method I) simply merges the multisensor data through the observation vector of the Kalman filter, whereas the second (Method II) combines the multisensor data based on a minimum-mean-square-error criterion. [11]. First method i.e. merging multisensory data using Kalman Filter has been used in this work due to ease in implementation.

II EXPERIMENTAL SETUP

Accelerometer Used: ADXL335 is a triple axis accelerometer. Tipple axis in the sense that it can measure acceleration along three axes viz x, y and z. The measured values appear as change in voltage at three output pins with respect to a common ground. The sensor measures acceleration with the help of a layer of polysilicon suspended above silicon wafer with the help of polysilicon springs. The motion of this mass is translated into the motion of the plates of a differential capacitor and thereby providing an output proportional to acceleration[12].

Hardware Block Diagram :

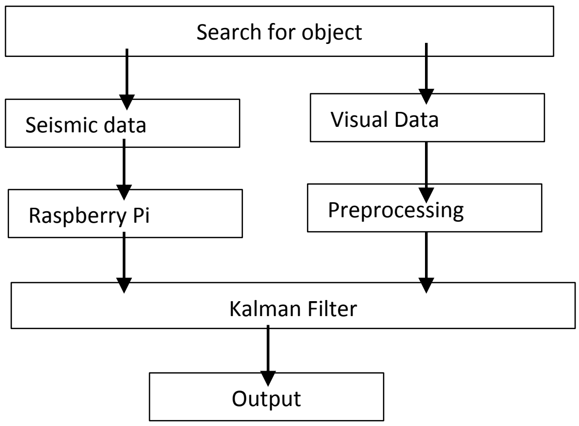


Initialization of Kalman Filter

In order to make Kalman Filter converge easily , proper initialization is necessary. It has been assumed that :

1. The accelerometer works within the range of 15 meter with uncertainty of 3 m^2.
2. The moving vehicle is about 1 meter away from the berm with uncertainty of $0.5m^2$.
3. The vehicle has zero initial speed and uncertainty of 10 $(m/s)^2$.

Software Design



1. Capture Image and Seismic data : this is done by using ADXL335 with Raspberry pi board with webcam.
2. Seismic Data is then preprocessed for noise removal.
3. Visual Data is preprocessed with Noise removal, thresholding and gray scale conversion.
4. Data is then fused with Kalman filter implemented on Matlab on Windows 10 Machine.
5. Output is taken in the form of trajectory of moving vehicle.

III. RESULTS AND DISCUSSION

Experiments have been performed on two video sequences herein referred to as Dataset1 and Dataset2. First one is moving vehicles on highways and contains 23 frames and second one is moving ball being occluded by box containing 45 frames. Figure 1 shows difference of measured and predicted value of object from video when no multimodality has been used. Figure 2 shows again the difference of measured and predicted value when we use the multimodal method with data fusion done using Kalman Filter.

It may be noted that multiple runs have been done and data obtained is averaged to achieve better generalization.

Results obtained and shown in Figure 1 and Figure 4 are from visual data only.

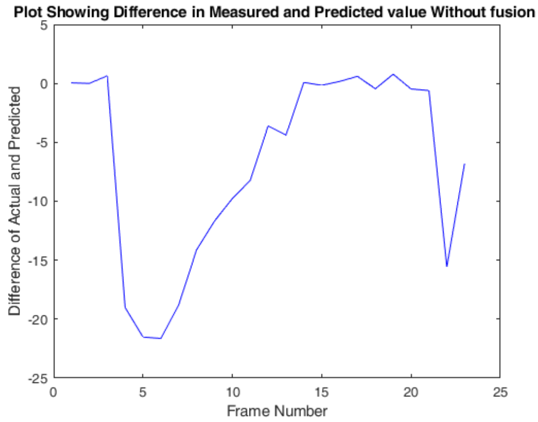


Figure 1: Difference of Measured and Predicted value Without using fusion

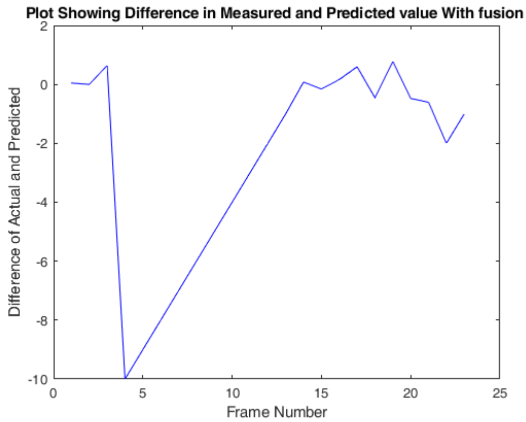


Figure 2: Difference of Measured and Predicted value with Data Fusion

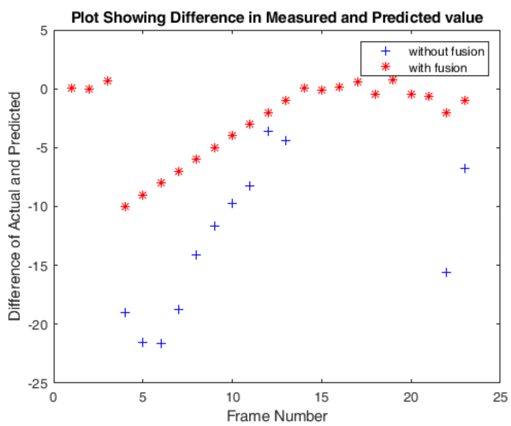


Figure 3: Comparison of Results using data fusion and without using data fusion on normalized scale.

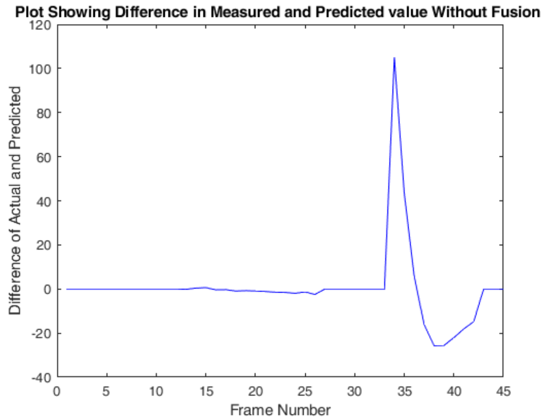


Figure 4: Difference in measured and predicted value without fusion for dataset2

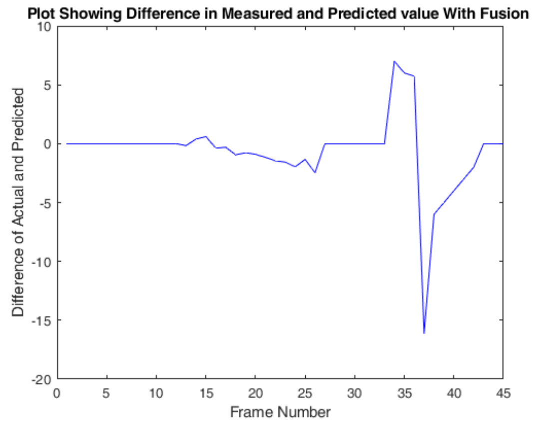


Figure 5: Difference in measured and predicted value with fusion

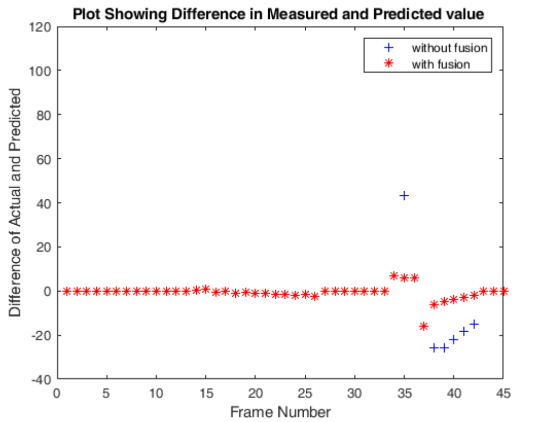


Figure 6: Plot showing with fusion and without fusion data on normalized scale.

It can be seen in Figure 1 and 4 that there is considerable difference between measured and predicted value in the first few frames due to error in initialization for Dataset1 and due to occlusion of object for Dataset2. Figure 2 and 5 is obtained for result obtained using Accelerometer and Visual data fusion again for Dataset1 and Dataset2 respectively. It can be seen that error has been reduced as compared to Figure 1 and Figure 4. Figure 3 and Figure 6 shows results on normalized scale for Dataset1 and Dataset2 respectively.

IV. CONCLUSION AND FUTURE SCOPE

In this paper a robust tracker has been proposed for occlusion handling using data from different modalities and fused using Kalman Filter. This method can accurately detect occlusions and minimizes error in predicted and measured values due to problems such as error in initialization or occlusion. Improvement in design is needed for handling multiple object tracking.

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