# A NOVEL EXPERIMENTAL SETUP TO STUDY SENSOR FUSION

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## Introduction

*Sensors are subject to noise when operating. In general, the price of the sensor is in direct relationship with the accuracy of the data being measured.*

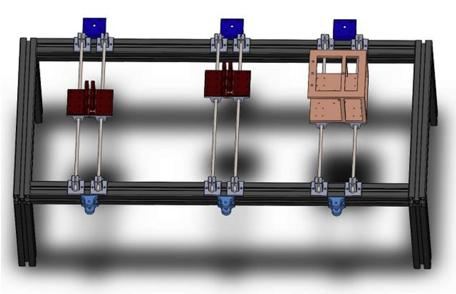
*One approach to overcome the noises is using sensors in complement with each other. In this scenario, the data assessed from sensors are relaying on the data being measured real time and data that measured previously. Relying on the previous data measurements suppresses abrupt changes which considered as high frequency noise and combination of these data with complementary sensors will result in a more reliable reading.*

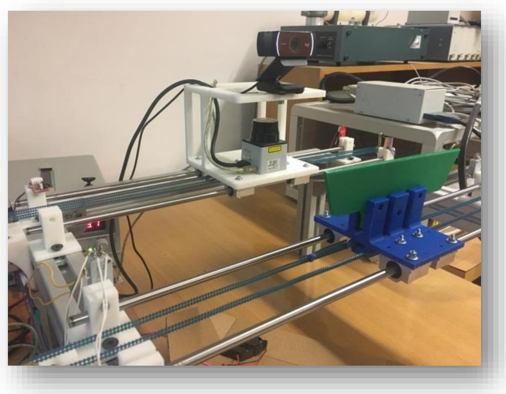
*The motivation behind this project is having data from sensors fused with each other in favor of a more accurate and reliable reading.*

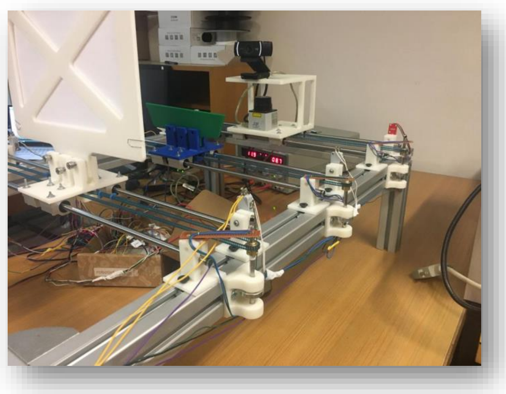
## Experimental Setup

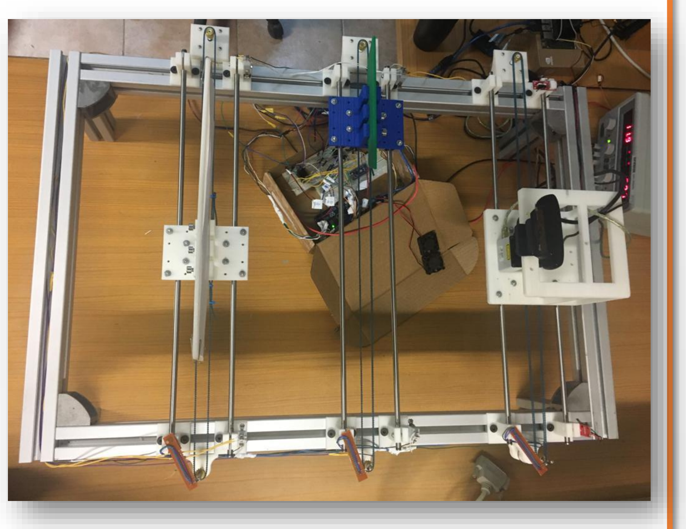
***Mechanical Setup***

- *Three linear axes*
- *Axes independent from each other*
- *Controlled using stepper driver and Arduino Mega*
- *Sinusoidal movement with configurable frequencies mimicking false data measurements*
- *Measurement of actual position using encoder for evaluation*









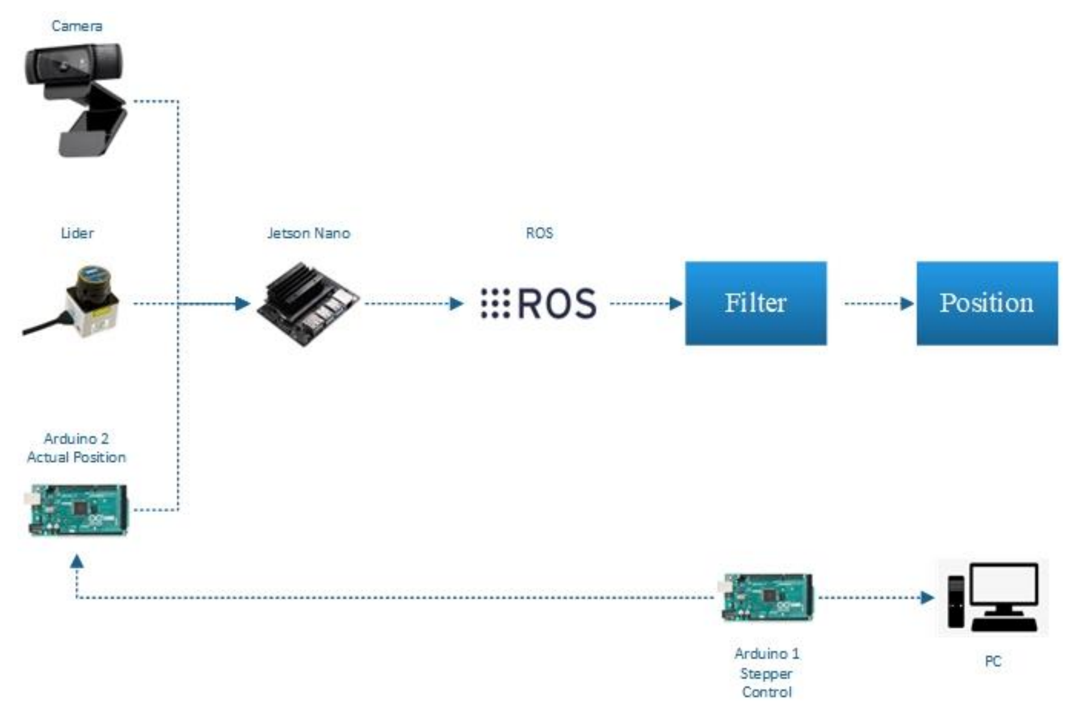
***Sensors and modules***

- *Logitech webcam as camera*
- *Hokuyo URG-LX04 lidar for range detection*
- *Hall effect sensor for positioning*

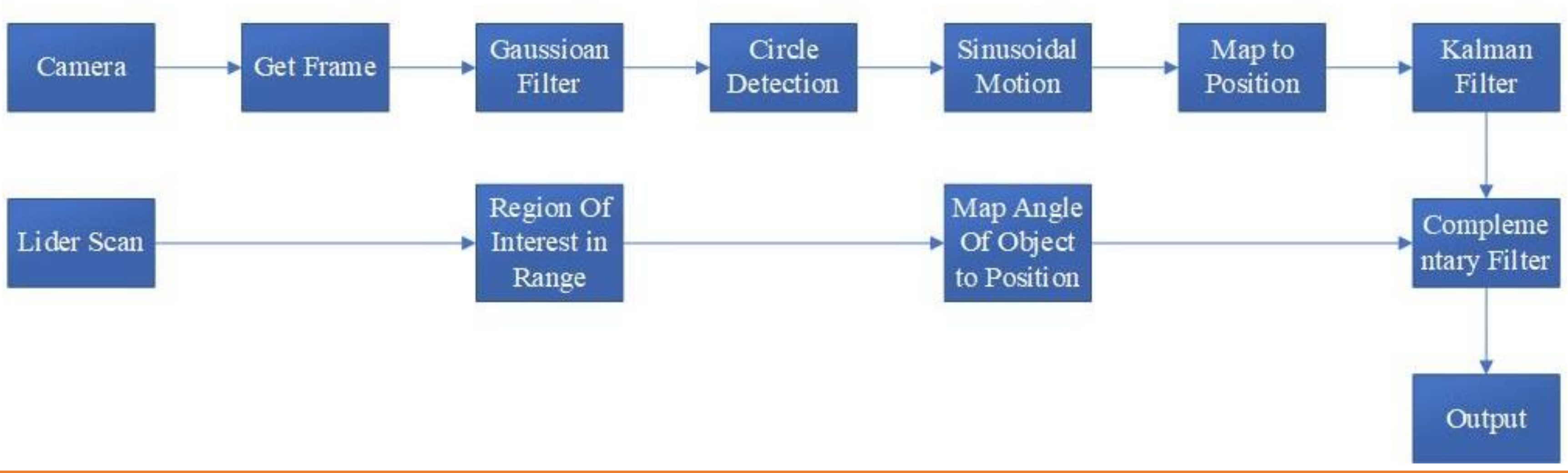
***Development Setup***

- *Robot Operating system (ROS) as development environment*


## Solution Methodology



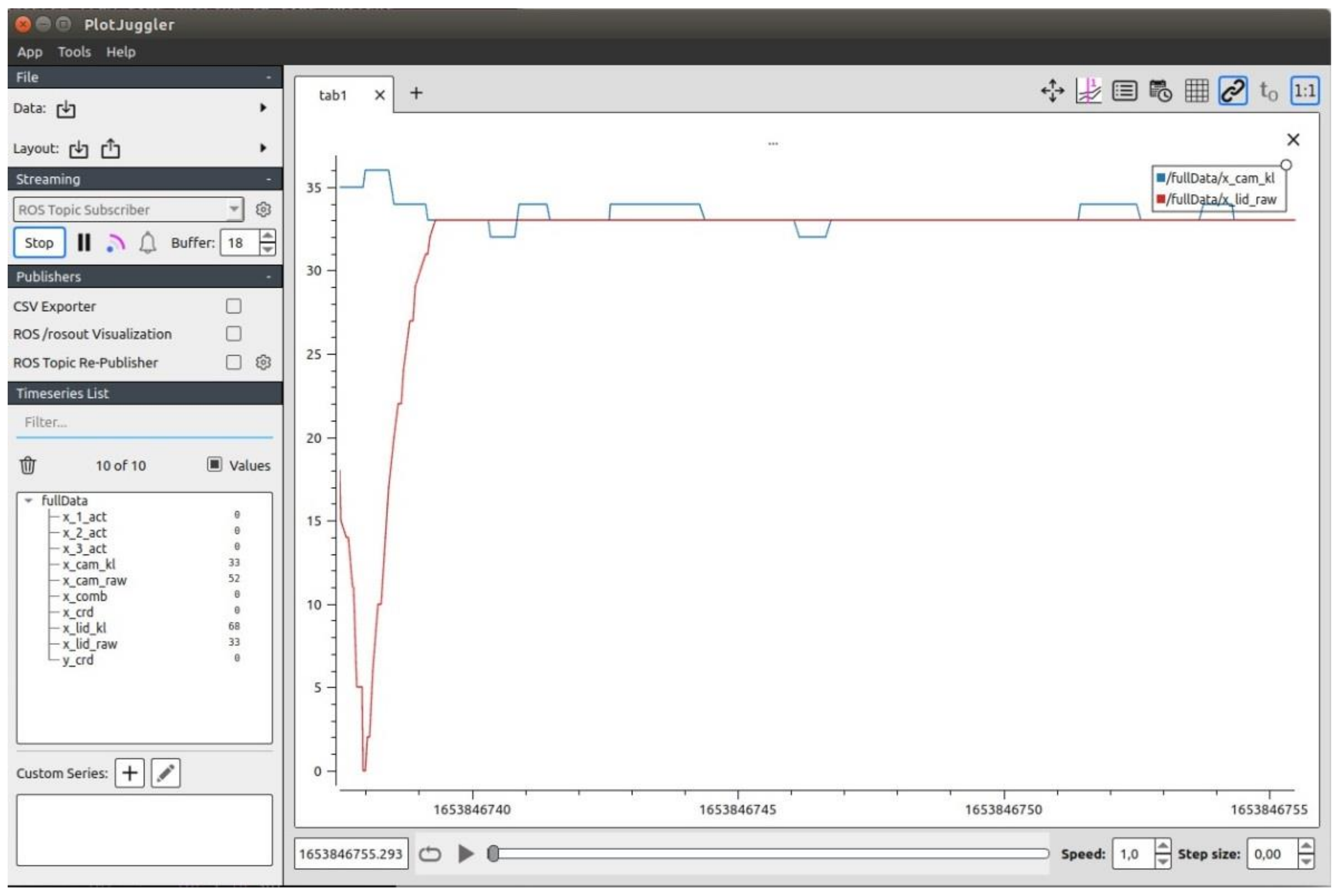

- *The complementary filter is weighted sum of the data*
- *The output data is being shown on juggler for real-time data streaming and plotting*
- *Camera and lidar data is collected using ROS packages*
- *Actual positions collected using encoder and published by Arduino (rosserial)*
- *Circles are found using camera and the pixel in which the center of the found circle is positioned will be mapped to the position relative to other axes*
- *Lidar data will be filtered to find region of interest*
- *Center of detected object found and mapped to the position relative to other axes*
- *Camera data will be passed to Kalman filter*
- *Data of lidar and camera are fused using complementary filter*




## Application Areas

- *Almost all navigation systems require filtering and in some cases sensor fusion.*
- *One application of sensor fusion is GPS/INS, where Global Positioning System and inertial navigation system data is fused using the extended Kalman filter.*
- *Smart watch step counting using IMU and GPS*

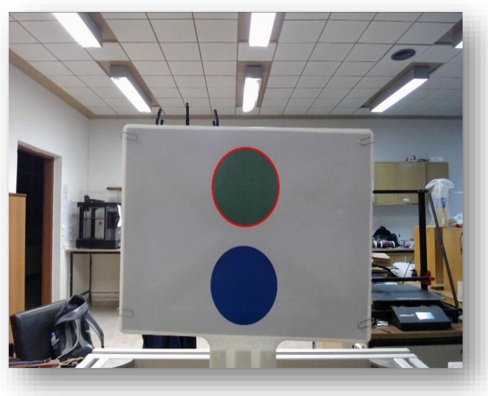
## Results and Discussion




- *Camera data, in contrary with lidar, collected at lower frequency*
- *Data is more consistent using Kalman filter for the camera*
- *Fusing data results in more reliable and convergent to actual value readings*

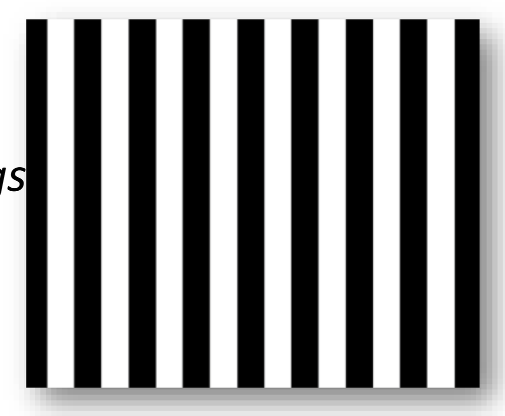
***Image based position:***

- *Two methods were experimented for assessing position based on the image. Finding stripes using template-matching and/or finding circles using Hough transform.*
- *Based on experiment, Hough transform results in more accurate results.*
- *The problem with stripes is the confusion that background causes.*



***Results and observations:***

- *The Kalman filter reduces noise and decreases the response of the system to abrupt changes*
- *Readings are based on the measurements as well. wrong measurement values will result in wrong readings the sensors should have acceptable accuracy as the Kalman filter will not compensate for the "always wrong" readings.*



## Acknowledgements

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❖ ***I thank Dr. Uyanik for his invaluable contributions to this project.***