**RALAZABA Electronics**

**Weekly Report**

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| **Done**  Two mouses self-localization method is tested.  We wrote test procedures for both mouse option and encoder readings |
| **To Do**  Encoder readings will be tested and compared with the the mouse option.  Kalman Filter will be constructed.  Mechanical design will be built. |

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| **Kalman Filter Road-Map**  At the conceptual design report, we proposed 5 different ways to sense the robot’s localization. We chose two methods together in order to prevent cumulative errors at the location and heading angle. Therefore, we decided to use a Kalman filter. In order to use a Kalman filter, we should have two measuring methods one is more accurate less frequent other one vice versa.  Our methods to sense location of the robot are two mouses method and encoder reading. To measure how much cumulative error can cause problems at the robot’s operation we wrote a test procedure for two mouse method. Our first thought is the mouse method has better accuracy but sensor data less frequent. The encoder readings are real-time but noisier. However, calculation errors of both two methods are crucial for filter design.  This week, we measure the error of two mouses method. Following week, we will test the encoders.  **C:\Users\nailt\AppData\Local\Microsoft\Windows\INetCache\Content.Word\Kalman_filter.png** |

Figure 1 Kalman Filter Block Diagram

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**Self-localization (State Observer) Test Procedure**

**Test Plan**

We want to use the 2 mouse method to solve the self-localization problem. In this method 2 separate mouse’s combined to measure both relative distance and heading angle of the robot. To measure errors of this method we planned a test plan.

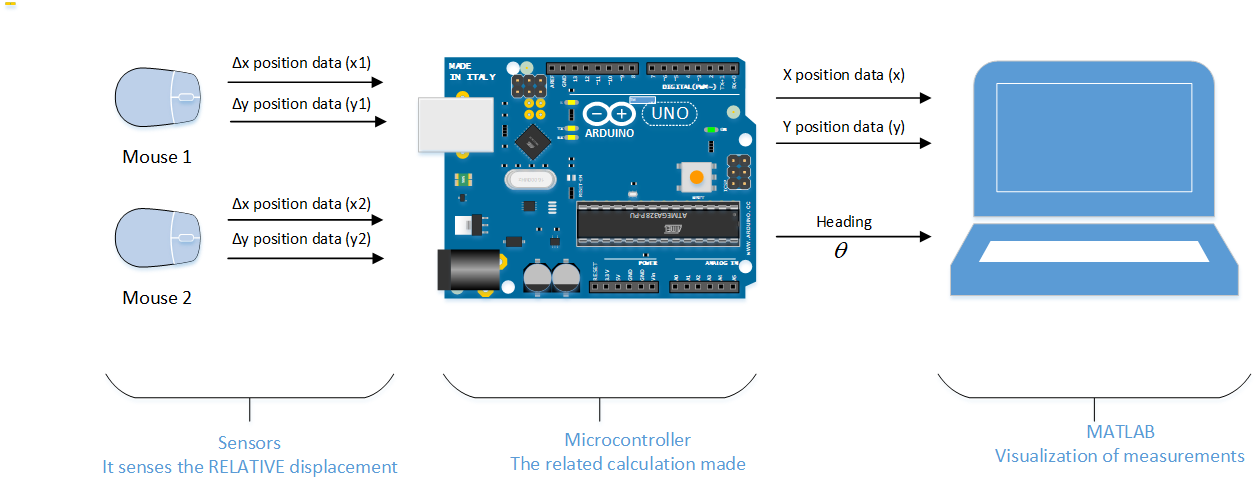


Figure 2 Block Diagram of the Test Plan

**Test Setup**

We read the sensor data with Arduino Nano. The related calculations made at MATLAB and Arduino environments. We measure the ground truth using millimetric papers.

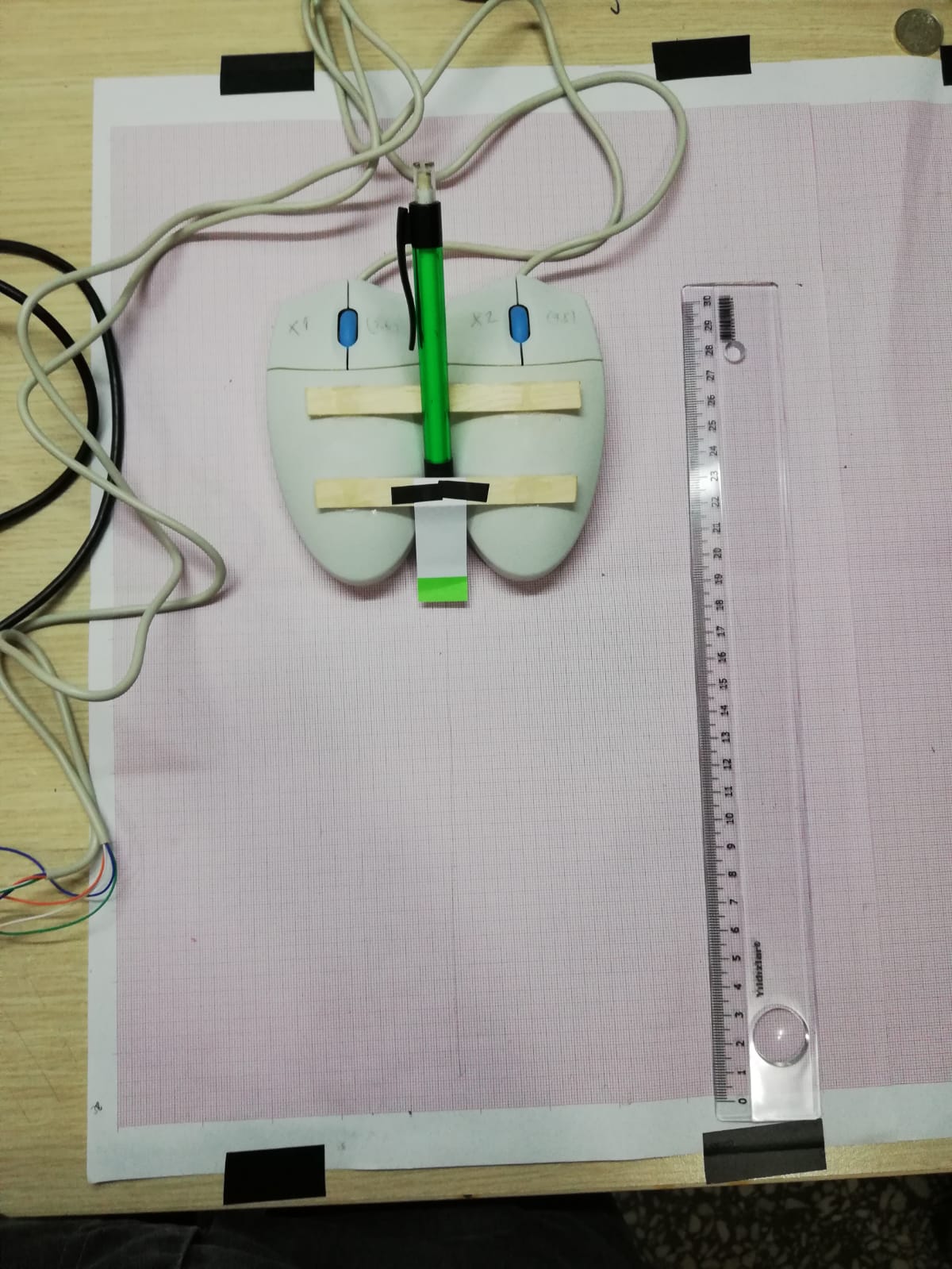


Figure 3 Test Setup

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| --- | --- |
| **Test** | **Expectation** |
| Straight Line 1 at a small distance | Is the unit measure the distance with MEA less than %1? |
| Straight Line 2 at large distance | Is unit measure the distance with MEA less than %1  Is the effect of cumulating the error seen? |
| 2 Direction movement at an acute angle  () | Is the unit measure the heading angle with MEA less than 1 ? |
| Arc (Quarter circle) | Is the unit measure the final destination with MEA less than %1?  Is the unit measure the heading angle with MEA less than 1 ? |

Table 1: Test Procedure

**Test Results**

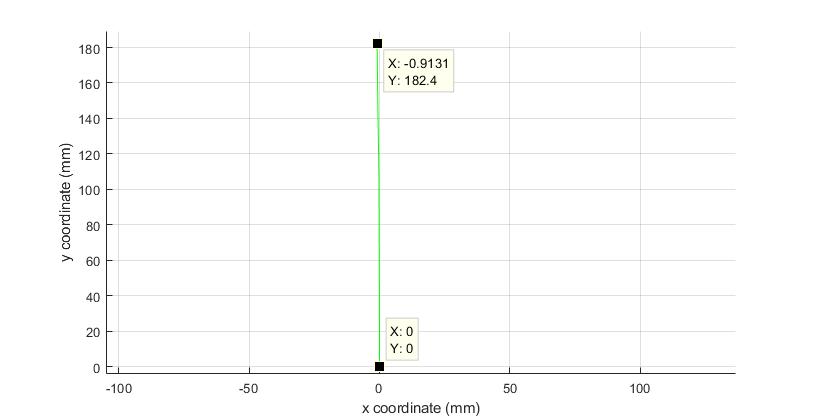
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Figure 4: Test 1 short distance measurement

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| **C:\Users\nailt\AppData\Local\Microsoft\Windows\INetCache\Content.Word\1.jpeg**  Figure 5: Test 2 Long distance measurement | **C:\Users\nailt\AppData\Local\Microsoft\Windows\INetCache\Content.Word\2.jpeg**  Figure 6: Test 3 heading angle |

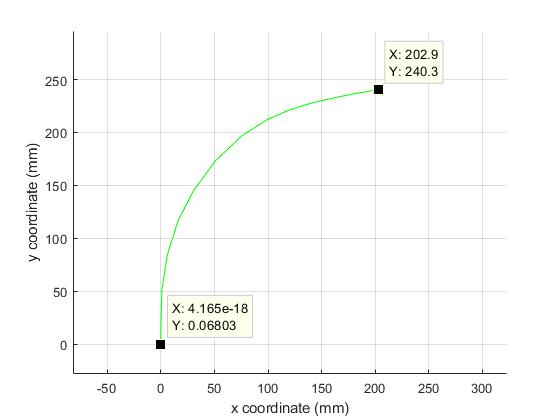
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Figure 7 Test 4 Arc

**Errors**

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| --- | --- | --- | --- |
| **Test No** | **Ground Truth** | **Measurement** | **Error PMAE** |
| 1 | x = 182 mm | x = 182.4 mm | 0.2 % |
| 2 | x = 350 mm | x = 349.6 mm | 0.11 % |
| 3 |  |  | 0.58 % |
| 4 | x = 210 mm  y = 210 mm | x = 202.9 mm  y = 240.3 mm | 7.9% |

Table 2 Errors

**Conclusion of the test**

From these test result we conclude that;

* Two mouse method high accuracy when the motion of basic. (Straight line, L shapes etc.)
* When the roadmap getting complex, the error due to measure is grow cumulatively. Therefore, roadmap algorithm should be robust or cumulative errors should be deleted via filters, i.e. Kalman filter.
* Very possible reason for failure at test for is our system is not sensitive lateral movements like in figure x
* In the case of differential drive there will be no direct horizontal movements or serious horizontal disturbances. Therefore, test 4 error is not critical for our sensing subunit. However, related software update will be constructed next week.



Figure 8: Illustration of horizontal disturbances

**Next Week Test Procedures**

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| **Test** | **Expectation** |
| Straight Line 1 at a small distance | Is the unit measure the distance with MAE<% 1? |
| Straight Line 1 at a long distance | Is the unit measure the distance with MAE<% 1?  Is the effect of cumulating the error seen? |
| 2 Direction movement at an acute angle | Is the unit measure the heading angle with MAE<% 1? |
| 2 Direction movement at a wide  angle | Is the unit measure the heading angle with MAE<% 1?  Is the effect of cumulating the error seen? |
| Arc (Quarter circle) | Is the unit measure the final destination with MAE<% 1?  Is the effect of cumulating the error seen? |
| Random Path | Is the unit measure the 5 random destination point with average MAE<% 1?  Is the unit measure the heading angle with MAE<% 1?  Is the effect of cumulating the error seen? |
| **Overall System (Conclusion)** | **Is the method satisfy our performance requirements?** |

Figure 9: Test procedures for both mouse and encoder methods