ENGR 6412

(Assignment 1)

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Submitted to

Dr. Krzysztof Skonieczny

Q1.

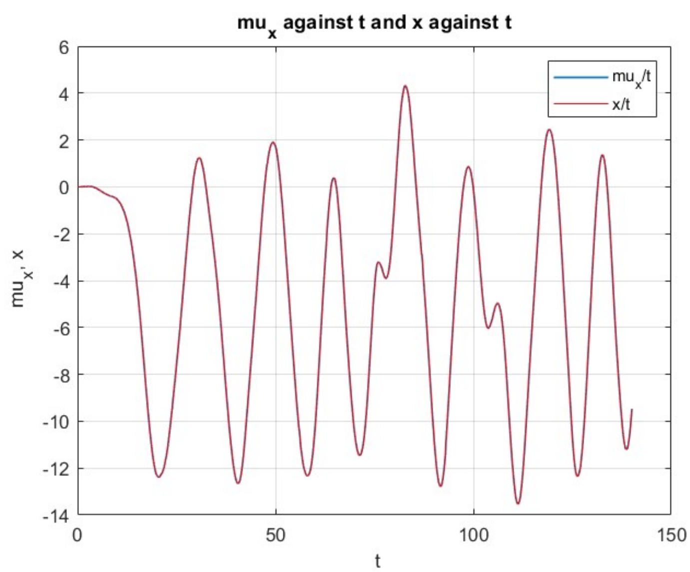
Please find the **Assignment.m** file in the attached folder.

Q2.

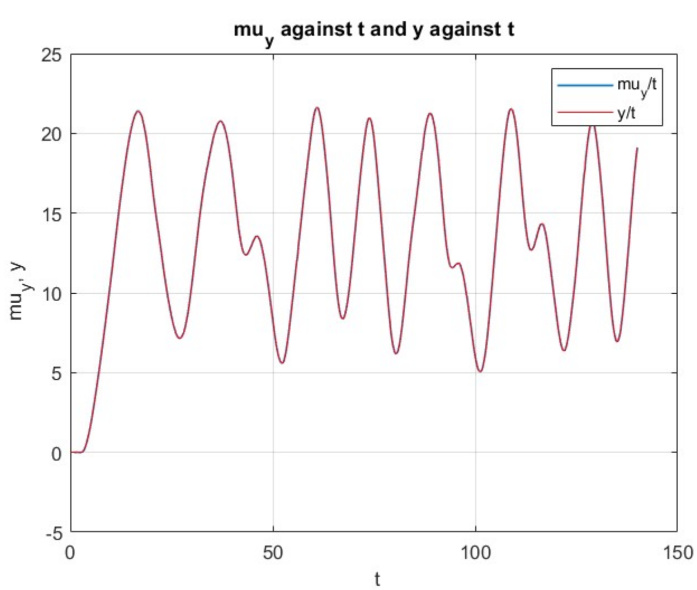
a) Plots

a-1) LandTamerGravel1_filtered.

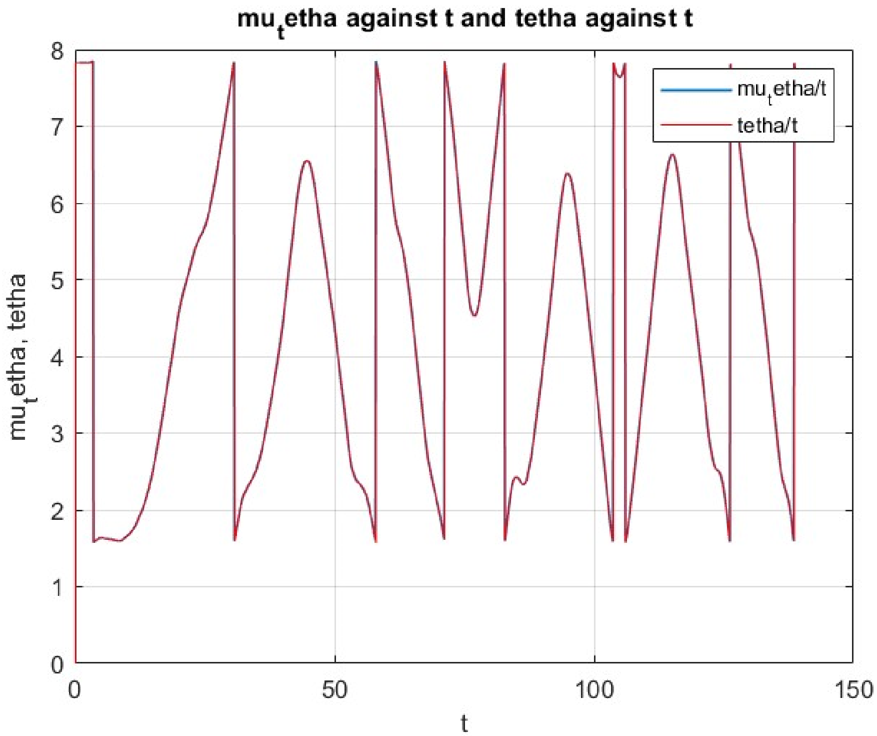
- **μ_x vs. t, z_x vs. t**



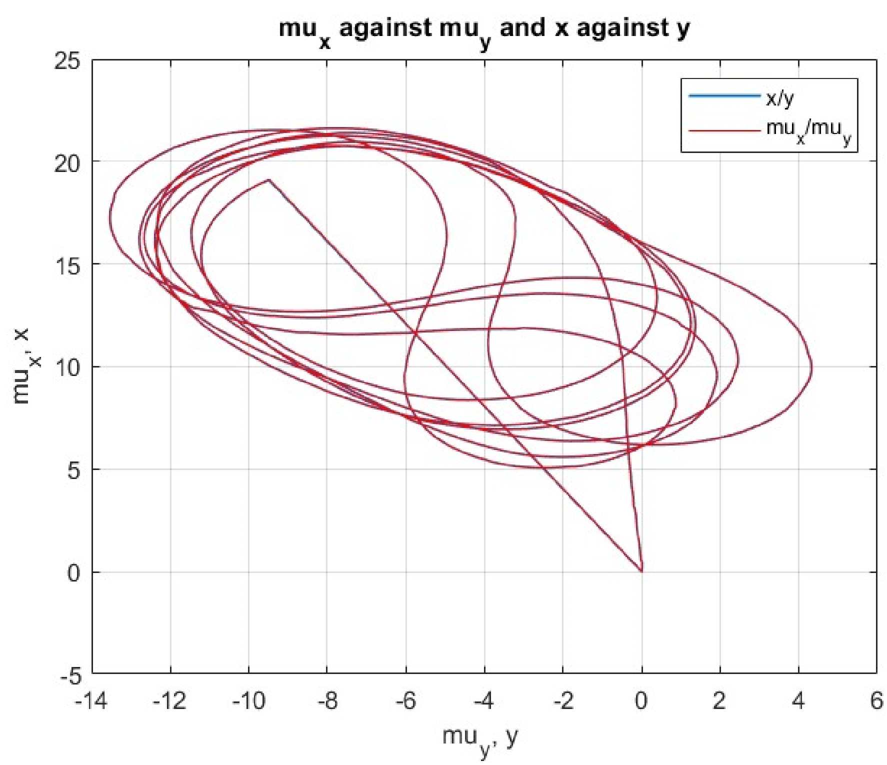
- **μ_y vs. t, z_y vs. t**



- **μ_θ vs. t, z_θ vs. t**

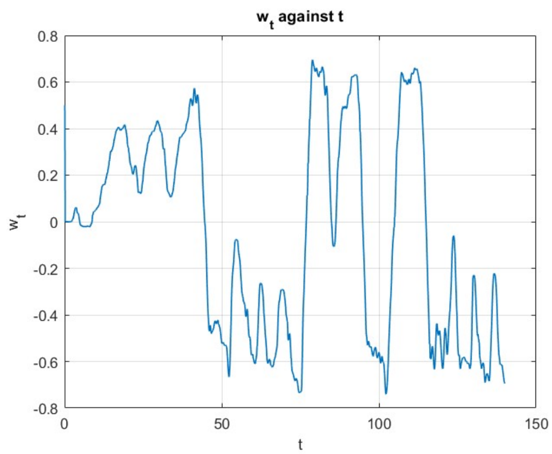


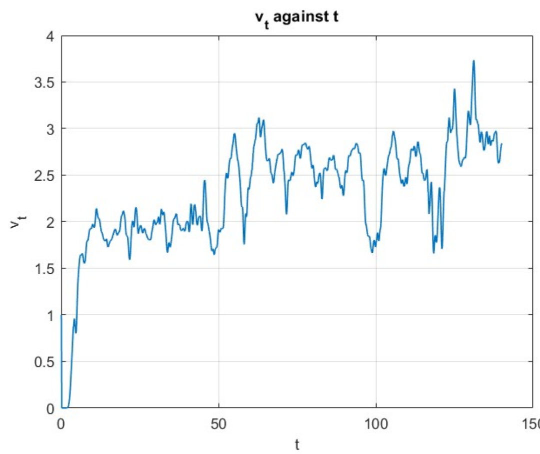
- **μ_x vs. μ_y , z_x vs. z_y**



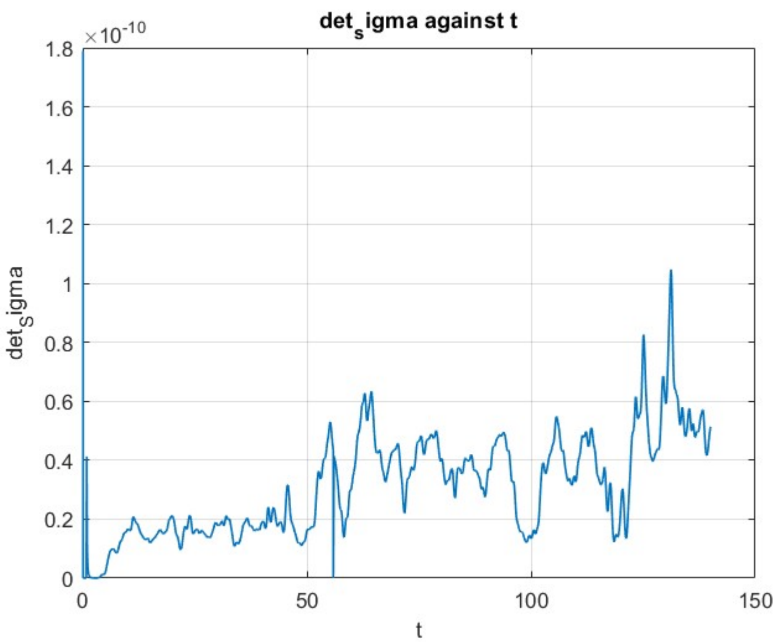
- **det(Σ) vs. t (v_t vs. t, ω_t vs. t)**

ω_t vs. t **v_t vs. t**



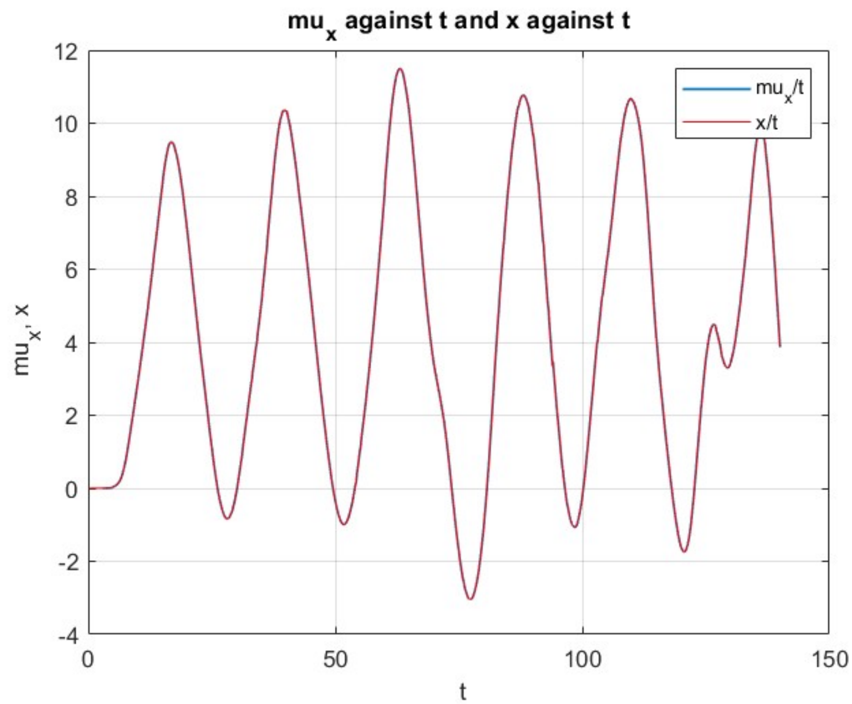


det(Σ) vs. t

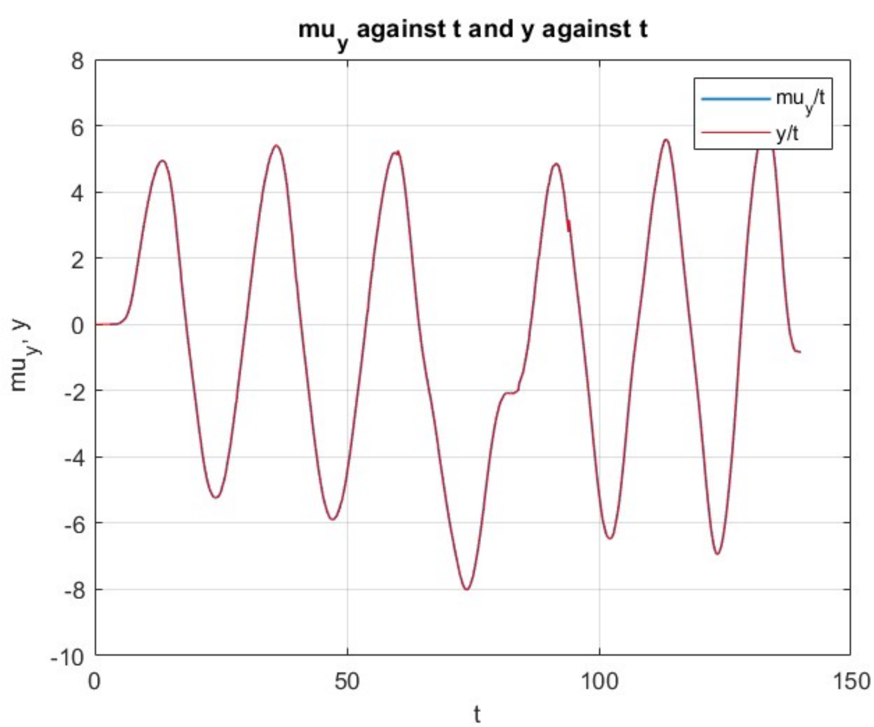


a-2) LandTamerGravel2_filtered

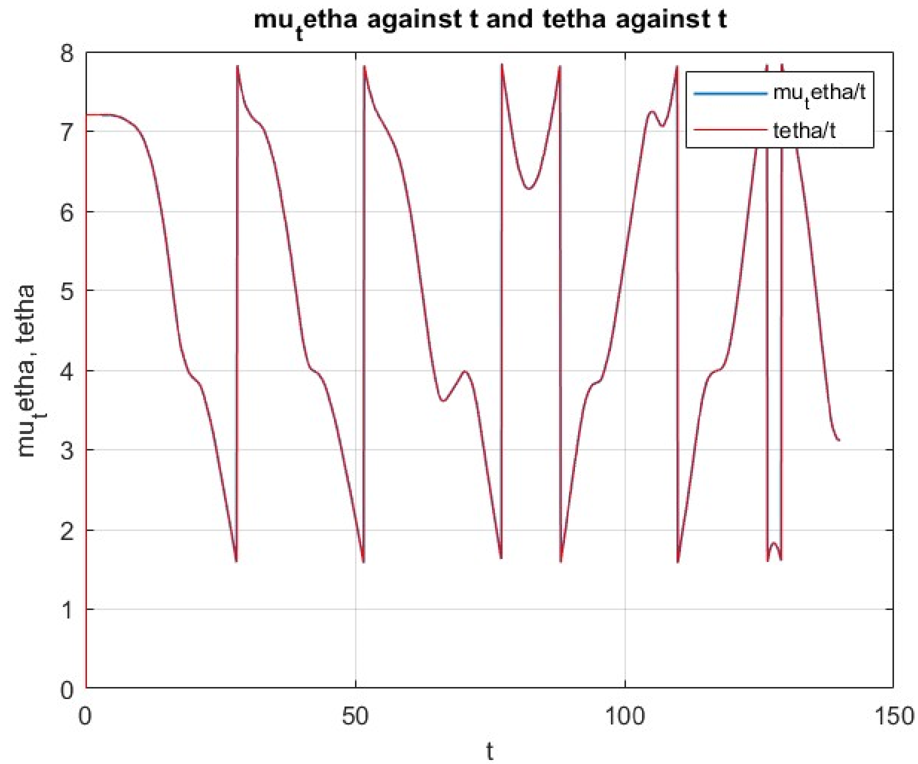
- **μ_x vs. t, z_x vs. t**



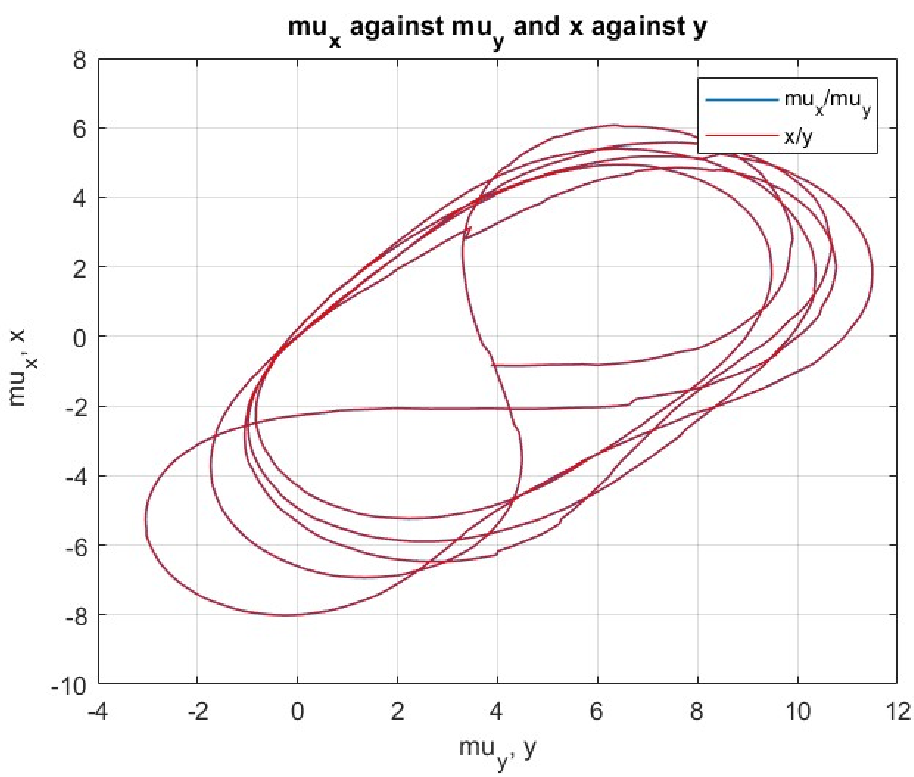
- **μ_y vs. t, z_y vs. t**



- **μ_θ vs. t, z_θ vs. t**

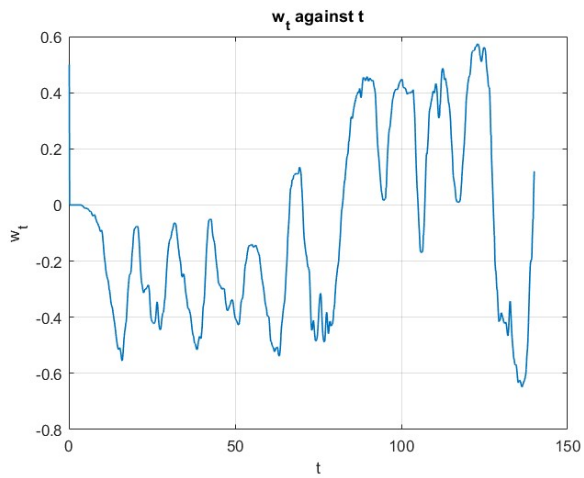


- **μ_x vs. μ_y , z_x vs. z_y**

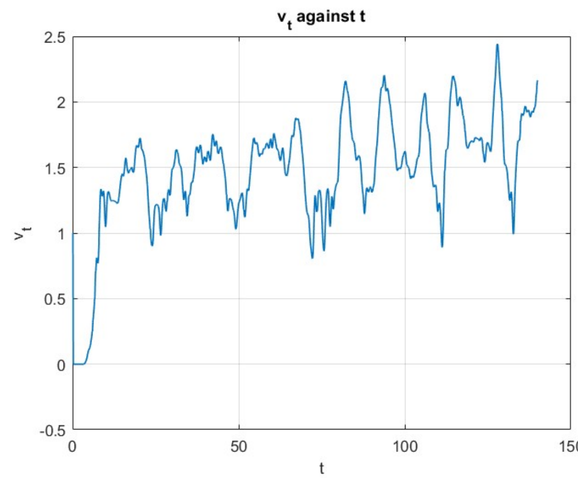


- **det(Σ) vs. t (v_t vs. t, ω_t vs. t)**

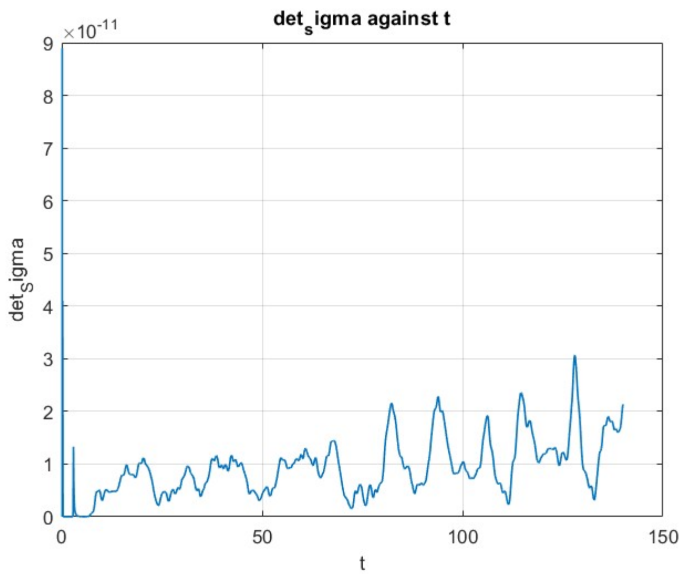
ω_t vs. t



v_t vs. t

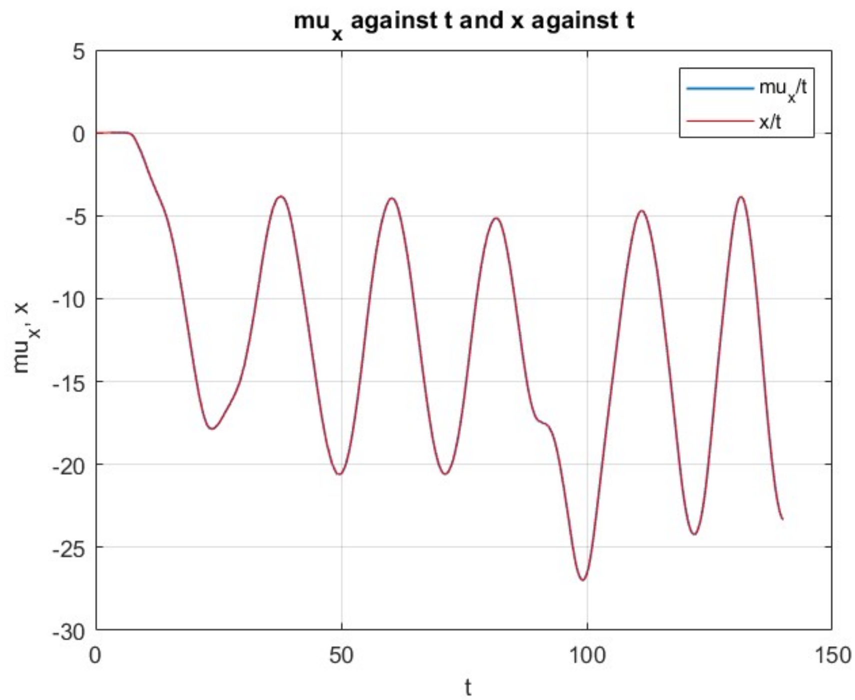


det(Σ) vs. t

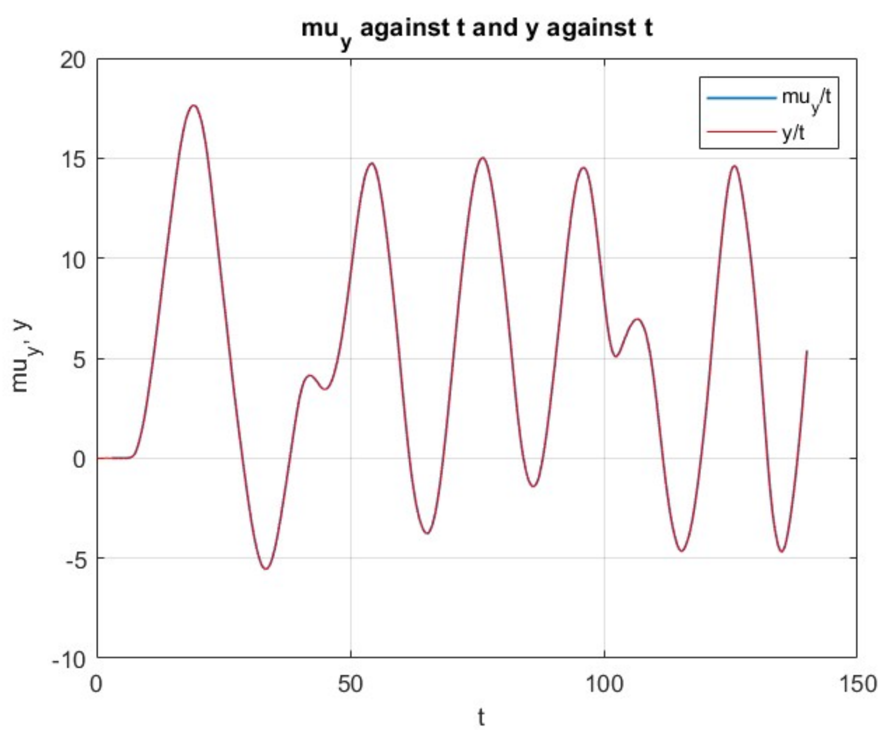


a-3) LandTamerLawn_filtered

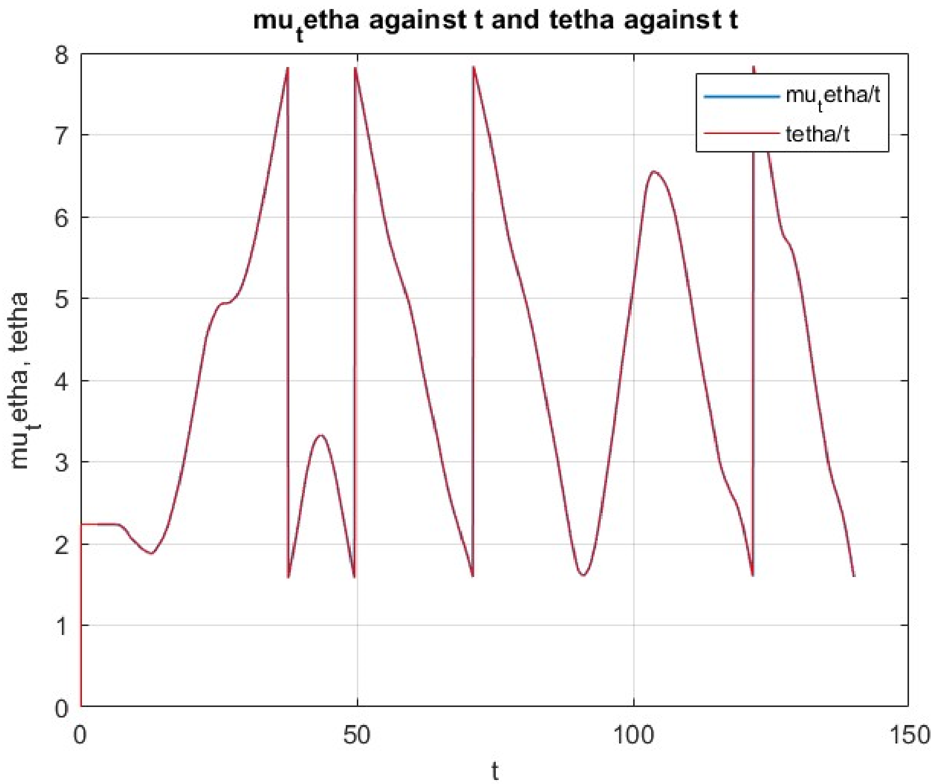
- **μ_x vs. t, z_x vs. t**



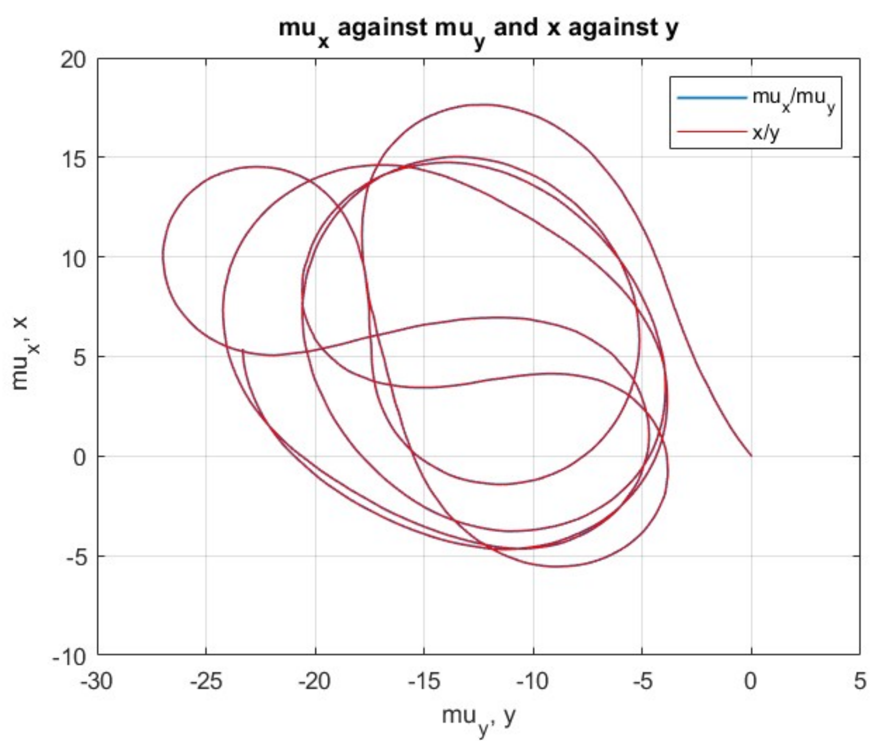
- **μ_y vs. t, z_y vs. t**



- **μ_θ vs. t, z_θ vs. t**

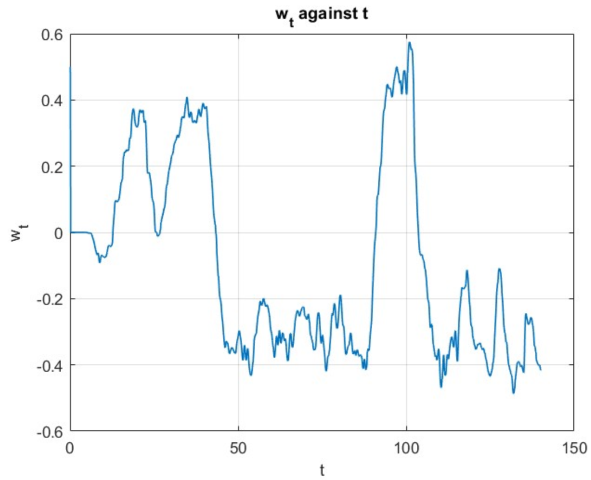


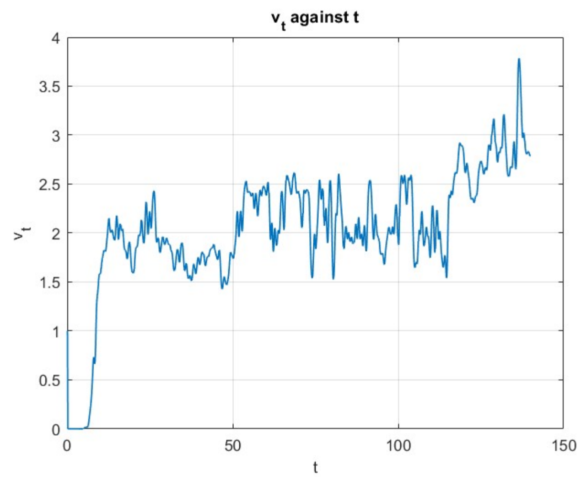
- **μ_x vs. μ_y , z_x vs. z_y**



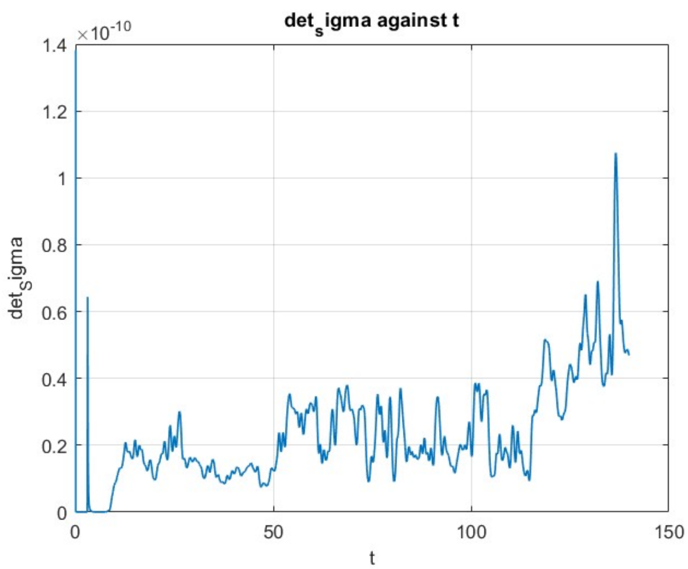
- **det(Σ) vs. t (v_t vs. t, ω_t vs. t)**

ω_t vs. t **v_t vs. t**



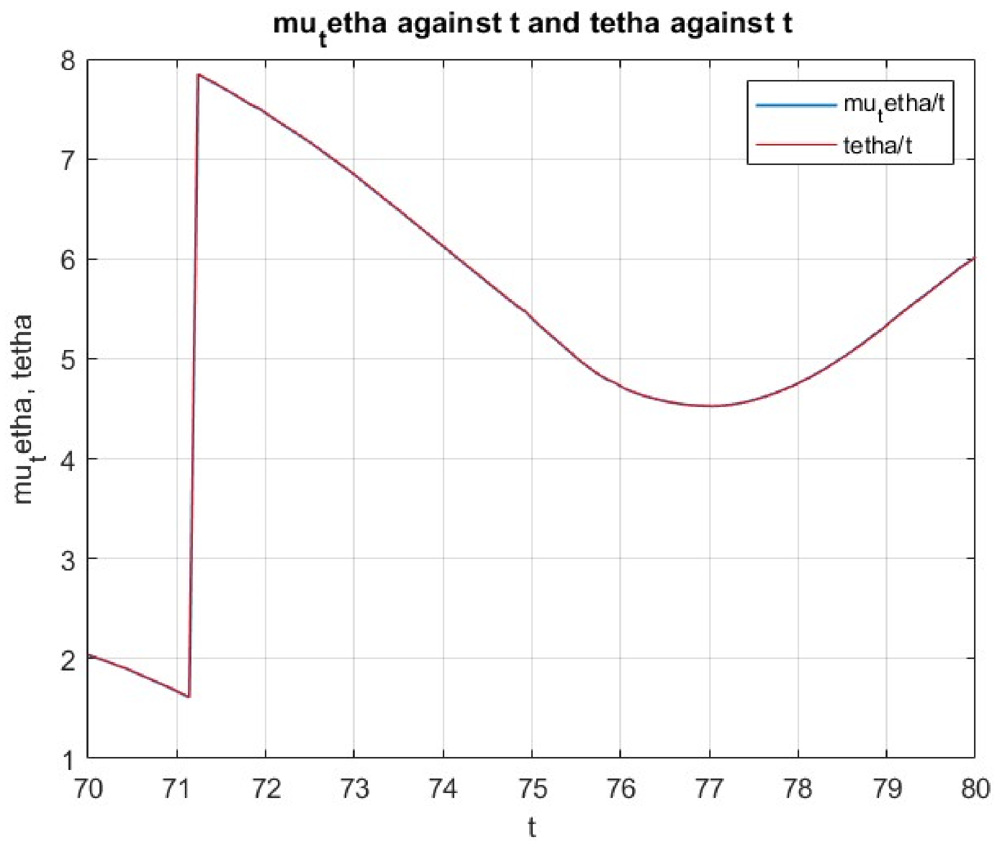


det(Σ) vs. t



b) Plot for LandTamerGravel1_raw dataset

μ_θ vs. t, z_θ vs. t (zoomed in focusing on t=70 s to t=80 s.)



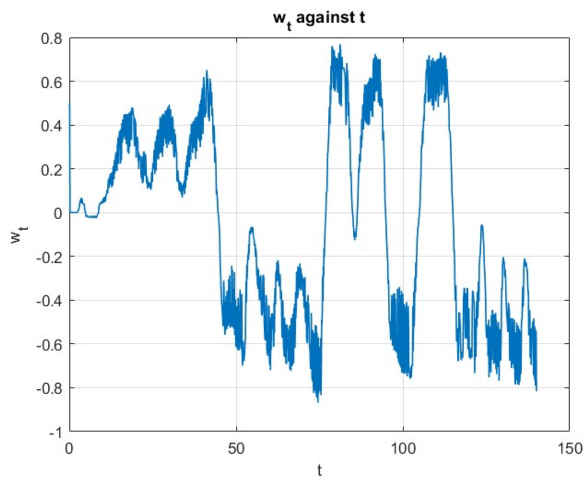
Q3.

a)

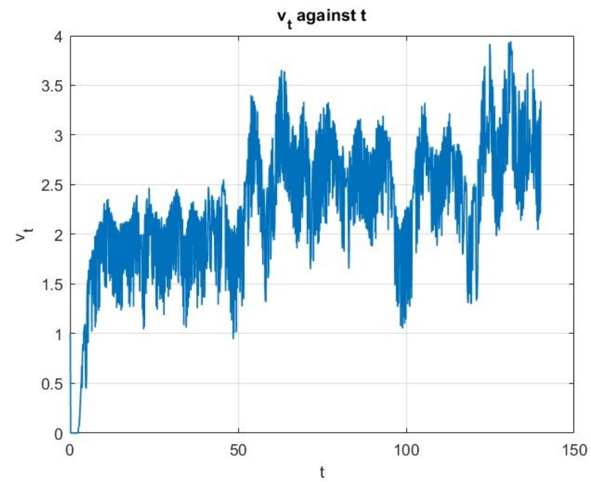
Significant variations in the commanded linear velocity (v_t) directly influence the uncertainty in the robot's state estimation, as observed in the ($\det(\boldsymbol{\Sigma})$) vs. (t) and ($v_t$) vs. (t) plots. Specifically, when the robot's velocity peaks around (t=131.13) s, the state estimation experiences maximum uncertainty. This relationship underscores the impact of velocity fluctuations on localization accuracy, emphasizing the need for precise modeling and error handling strategies during high-velocity maneuvers.

LandTamerGravel1_raw dataset

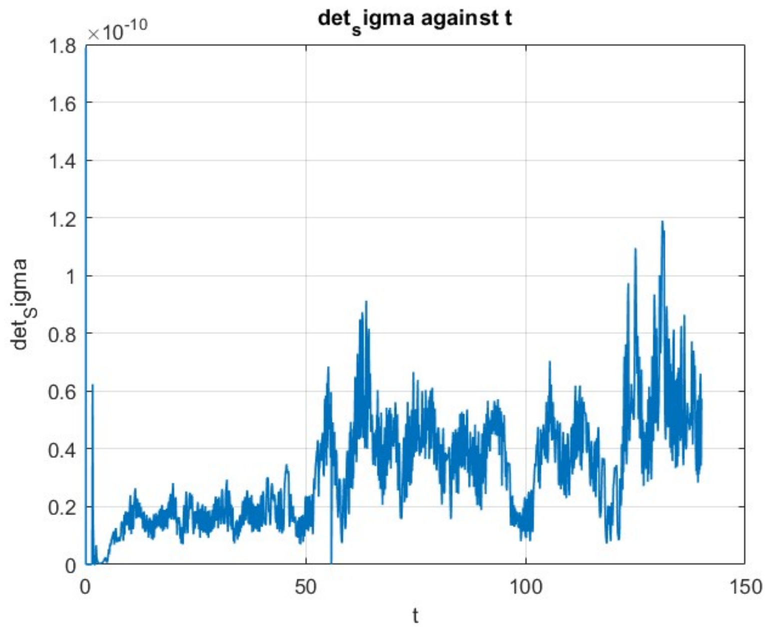
ω_t vs. t



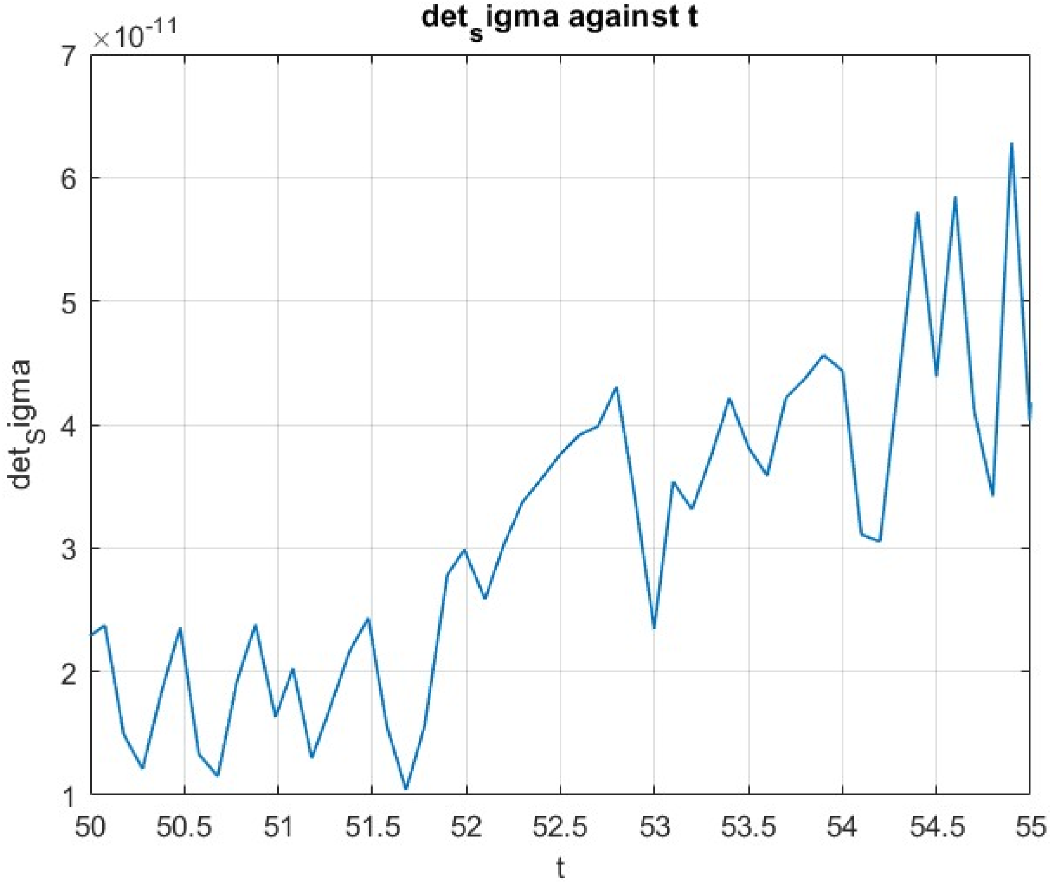
v_t vs. t



det(Σ) vs. t



b) Plot for det(Σ) vs. t (zoomed in focusing on t=50 s to t=55 s.)

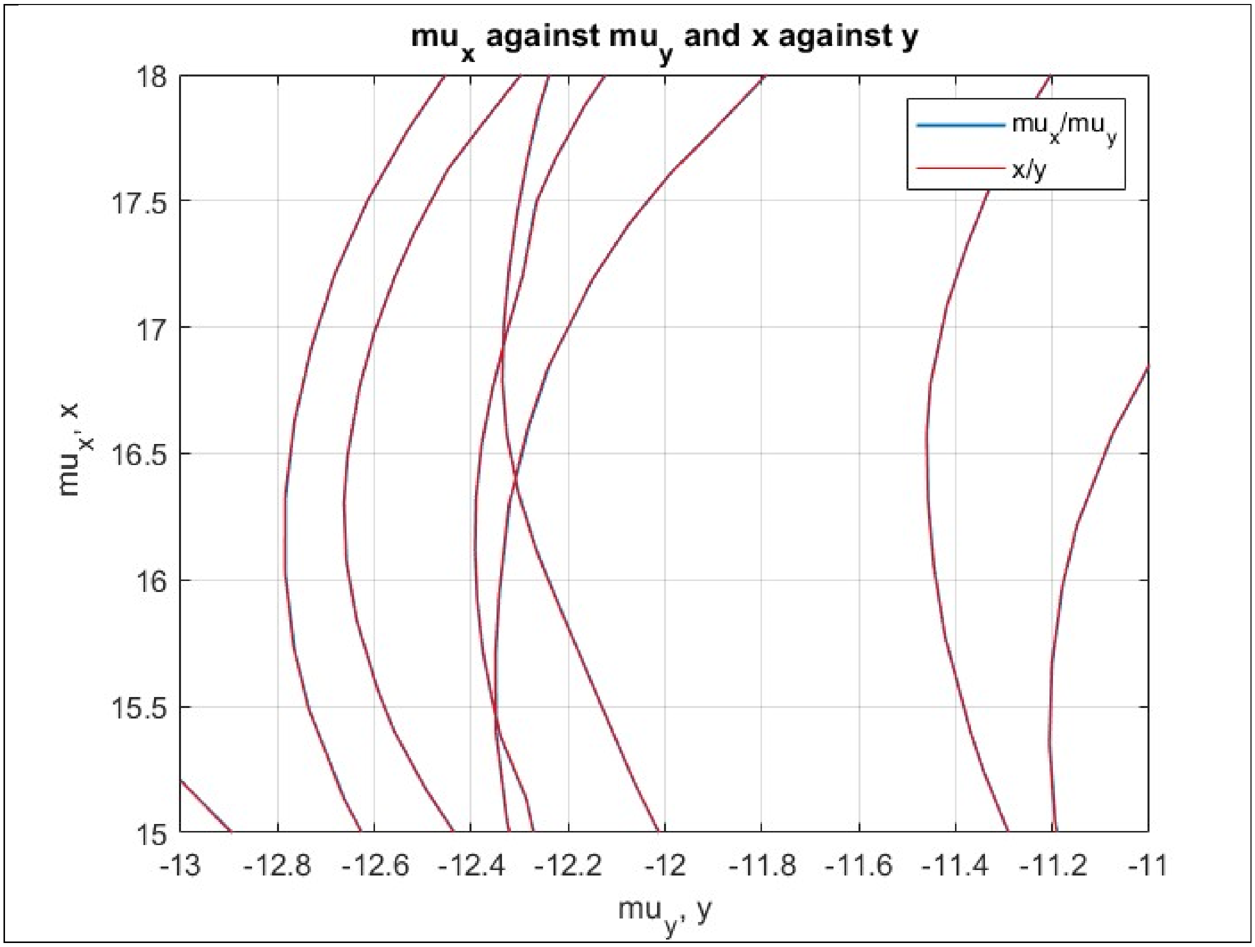


Measurement of the state is acquired through a sensor, and these measurements undergo a correction process. During this correction, the system becomes much more certain of its state estimations, and therefore the determinant of the state estimation covariant matrix is significantly reduced, you can see that in 51.75 second it reaches the minimum amount. After correction, the system continues with predictions until new measurement data is available, at which point the estimates are corrected once more. When the vehicle moves at high speeds, uncertainties in the estimates escalate rapidly. This occurs because greater velocity introduces larger errors, amplifying the uncertainty in state estimation.

Q4.

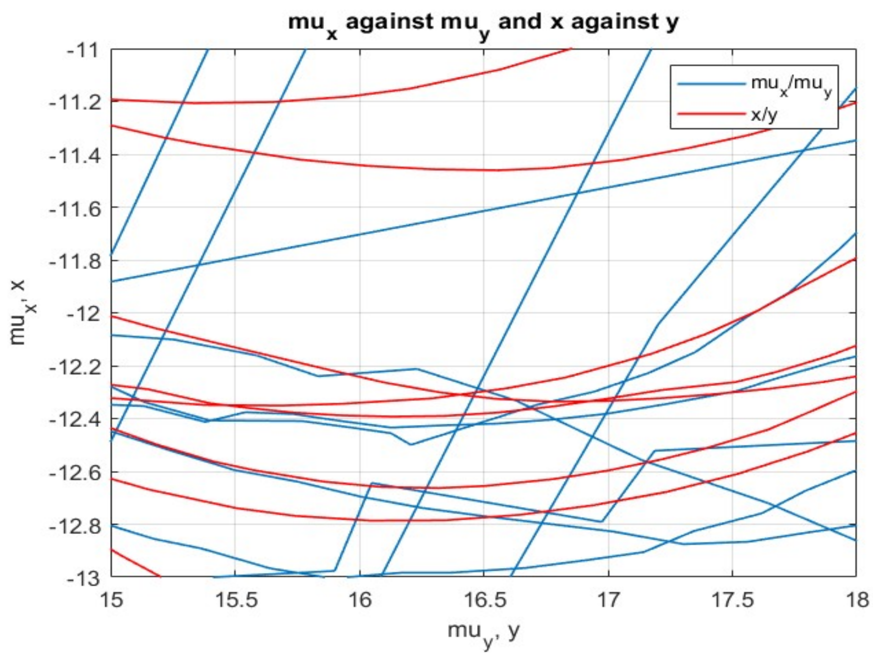
a) LandTamerGravel1_raw dataset

μ_x vs. μ_y , z_x vs. z_y (zoomed in on the region [x ={-13, -11}, y = {+15, +18}])

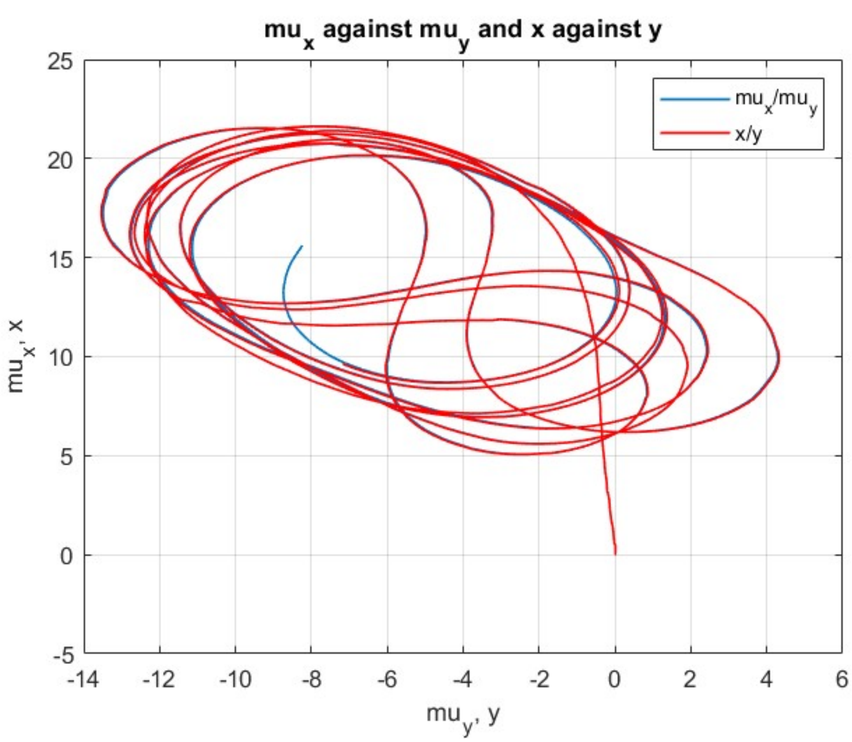


b) μ_x vs. μ_y , z_x vs. z_y (zoomed in on the region [x ={-13, -11}, y = {+15, +18}])

rerun the $\alpha_1, \alpha_2, \alpha_3, \alpha_4 = 1e9$



c) μ_x vs. μ_y , z_x vs. z_y - rerun the $\alpha_1, \alpha_2, \alpha_3, \alpha_4 = 1e-9$



d)

If we increase the α coefficients in the velocity motion model of your Extended Kalman Filter (EKF), we are essentially increasing the assumed uncertainty in the velocity control inputs. In the context of EKF localization, the motion model predicts the robot's next state based on its current state and control inputs.

By increasing the α coefficients, you are telling the EKF that you have less confidence in the accuracy of your velocity commands. Consequently, the predicted state will have a higher uncertainty associated with it, leading to a larger error covariance matrix (R) after the prediction step. This larger uncertainty in the predicted state affects how much the filter trusts its predictions.

If a = 1e9: comparing this with the measurement error Q the control input errors are significantly larger. the system should heavily rely on sensor data over the motion prediction model.

If a = 1e-9: Nearly there are no errors in inputs. Therefore, when compared the measurement errors with Q, the motion prediction model should be reliable over the sensor data. Thus, motion prediction model appears to be all that is considered.