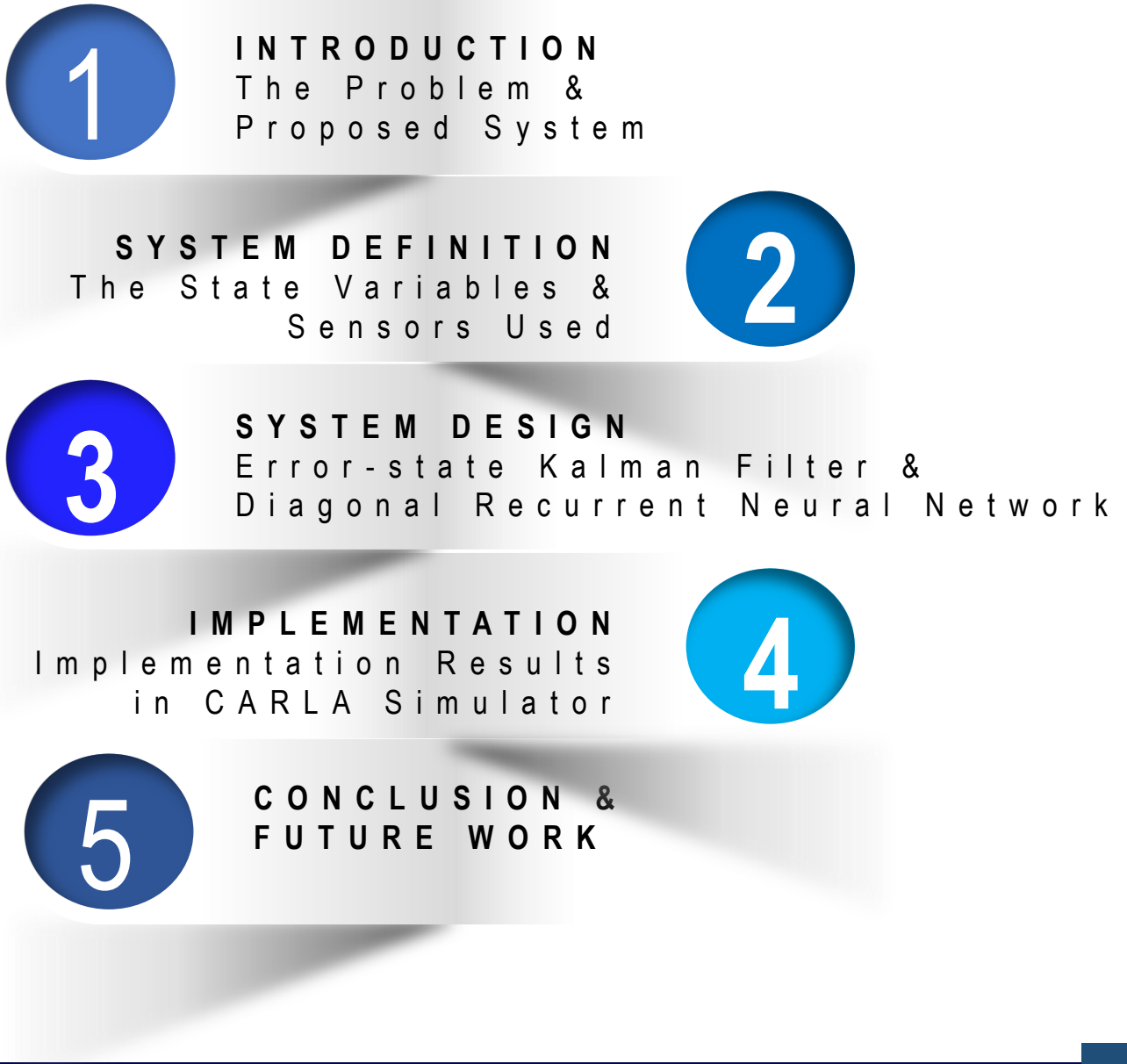
Localization Method for Autonomous Car Using Virtual Sensing System

Yul Y. Nazaruddin, Fadillah A. Ma'ani, Prasetyo W. L. Sanjaya, Eraraya R. Muten, Gilbert Tjahjono, Joshua A. Oktavianus

Presented by

Eraraya R. Muten

Outline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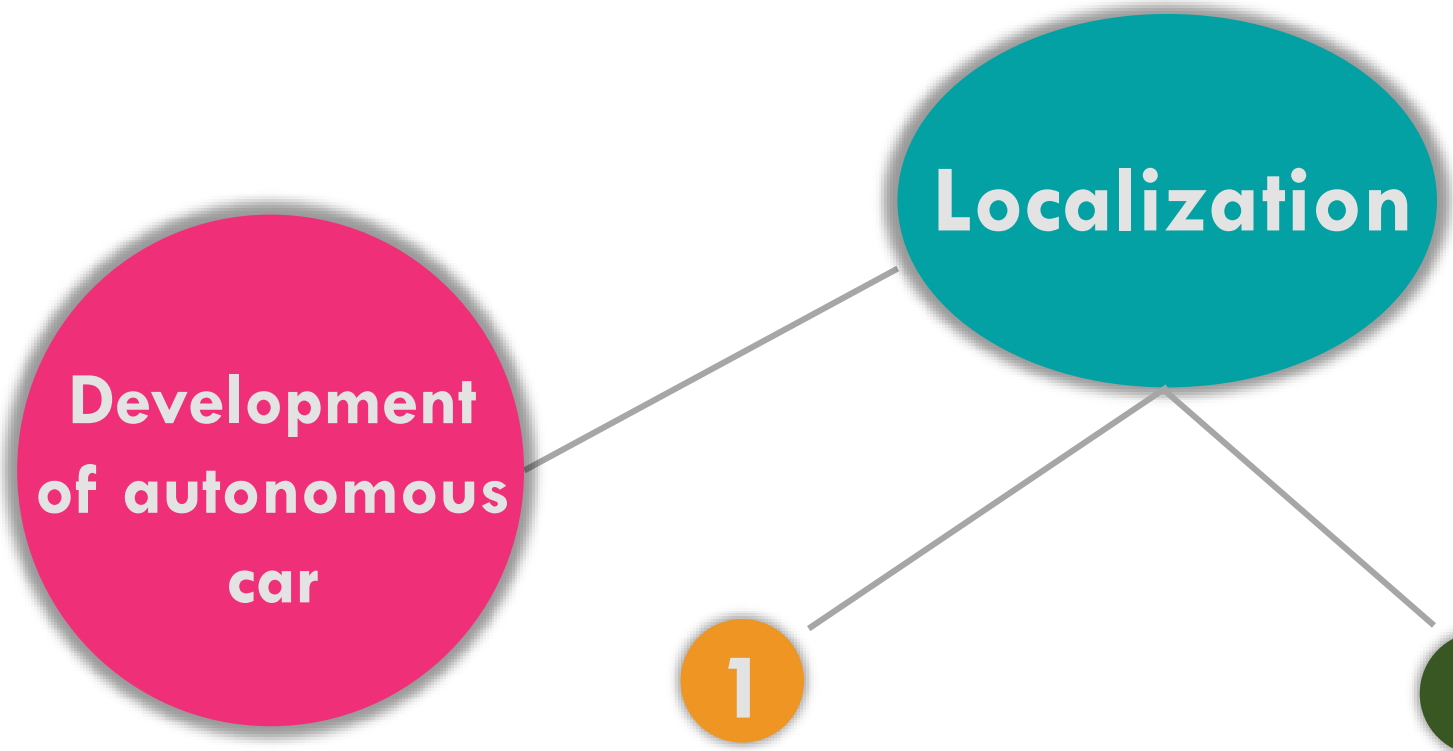
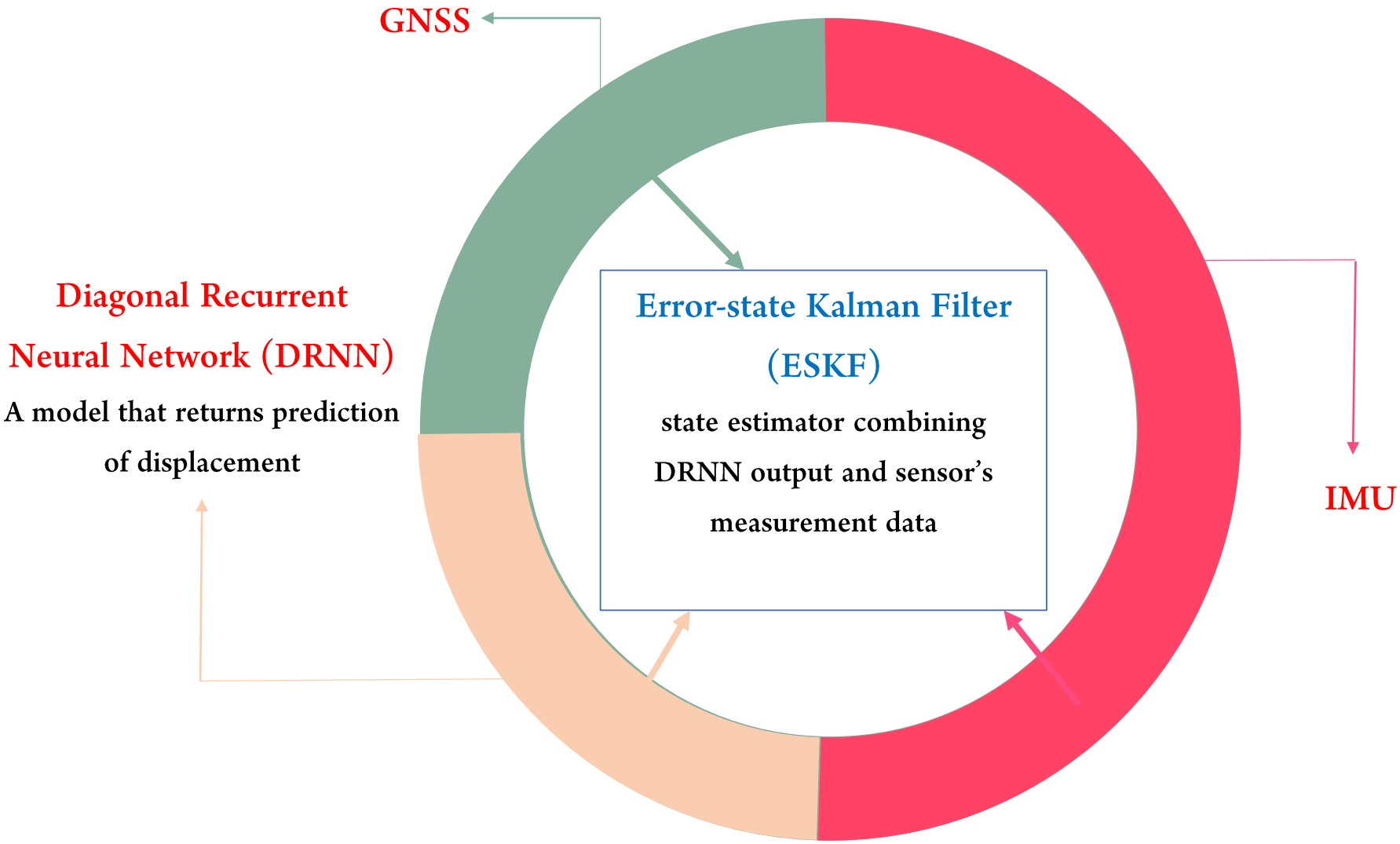
Introduction: Problems



Introduction: Proposed Localization System



System Definition: State Variables

Estimated State Variables

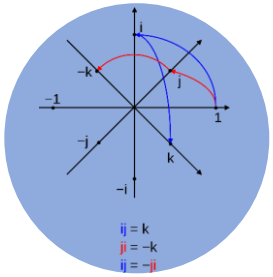
are estimated with respect to inertial frame (e.g. the Earth)

Position

Together with orientation state, is used to determine the next steering angle

Velocity

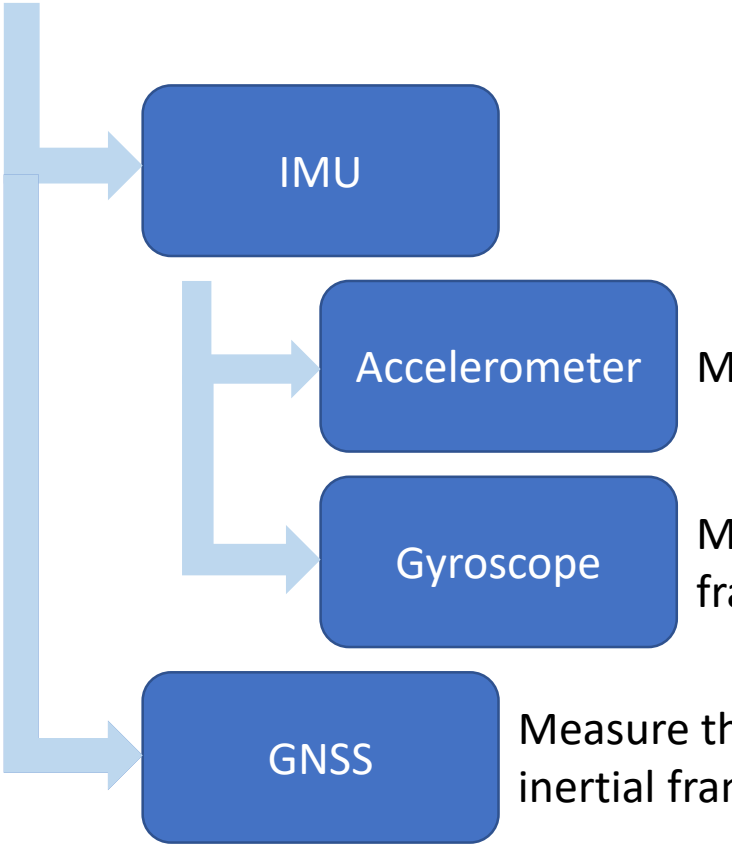
Is used to determine the next throttle and brake



Orientation

Quaternion system is used to describe the car's orientation

System Definition: Sensors Used

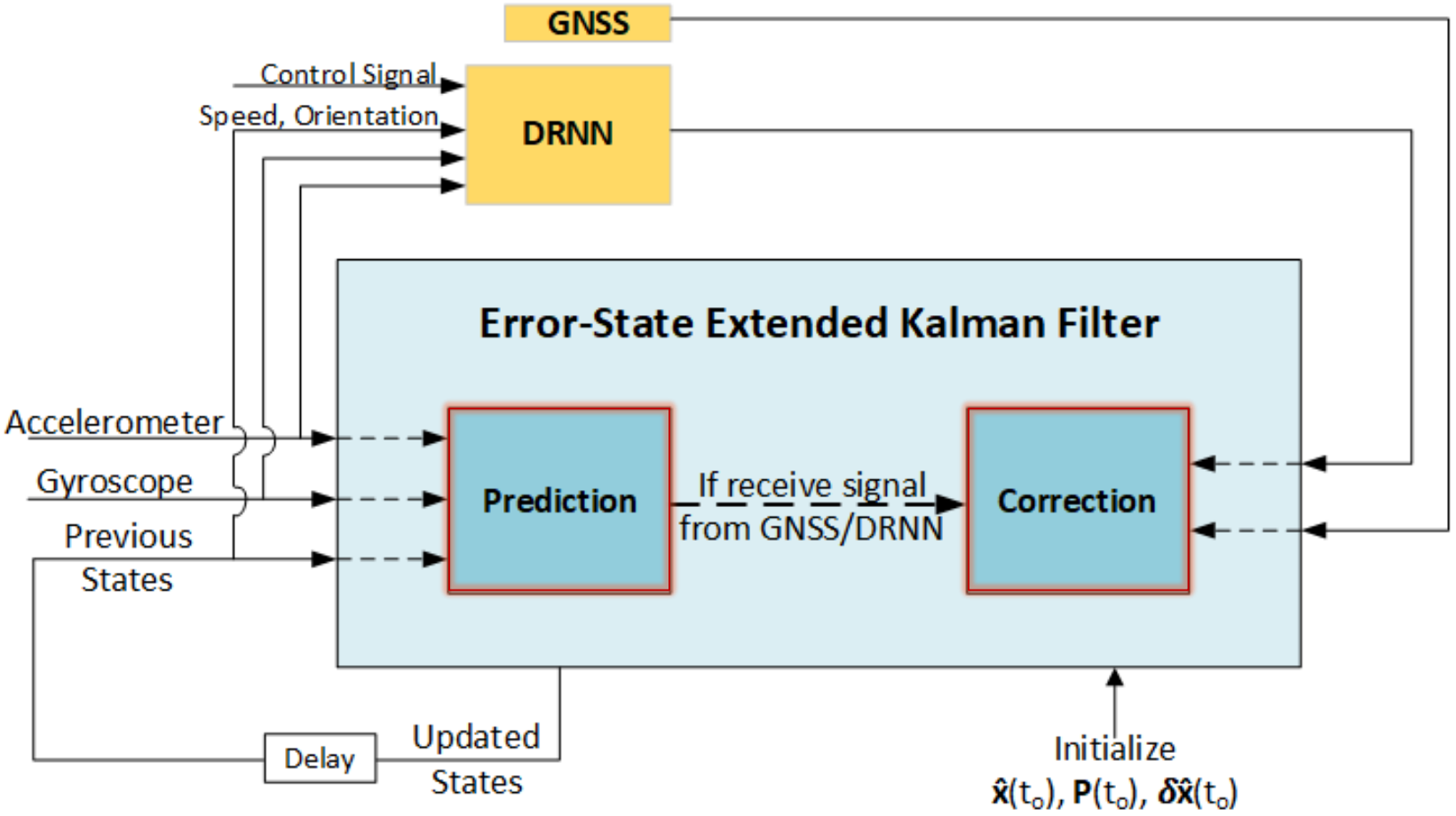


Measure the car's acceleration in vehicle frame

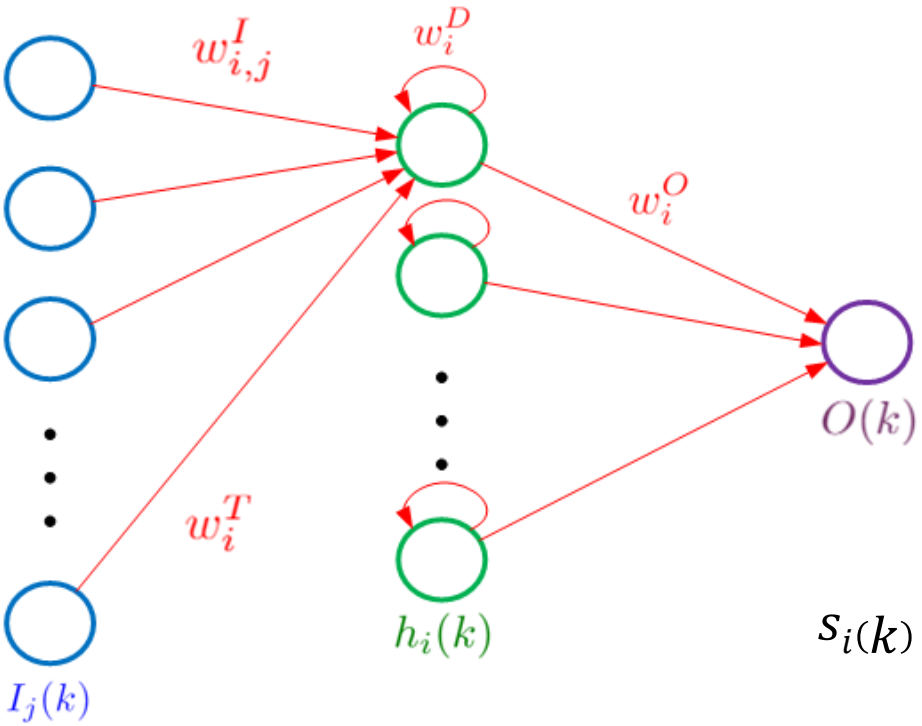
Measure the car's angular velocity in vehicle frame

Measure the position of the car with respect to inertial frame (e.g. earth)

System Design:
Error-state Kalman Filter



System Design:
Diagonal Recurrent Neural Network (DRNN)



Recurrent Neural Network: Processes a sequence of data, one at a time while retaining a memory about what data has come previously in the sequence

DRNN, a simplified version of fully-connected RNN (FRNN), is used to assist the GNSS and can replace it if needed

$$h_i(k) = max(0, s_i(k))$$

$$s_{i(k)} = w_i^D . h_{i(k-1)} + \sum_j^n w_{i,j}^I . I_{j(k)} + w_i^T$$

$$O(k) = \sum_i^m w_i^O . s_i(k)$$

$$J(k) = \big(L(k) - O(k)\big)^2$$

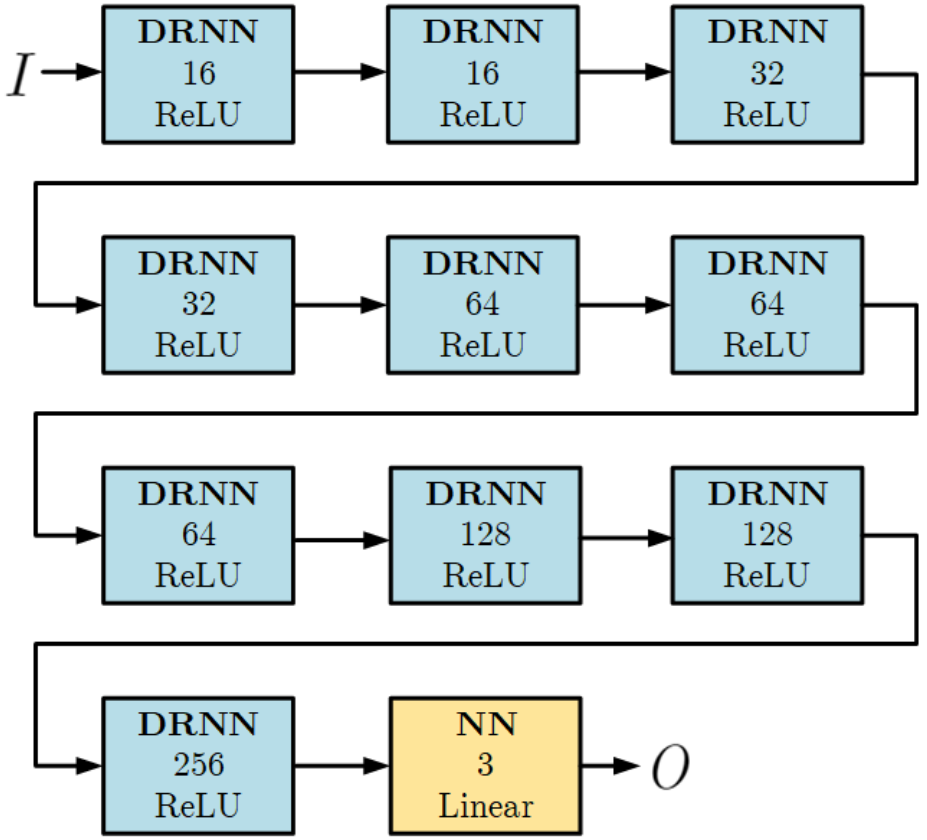
System Design: DRNN Architecture

16 inputs

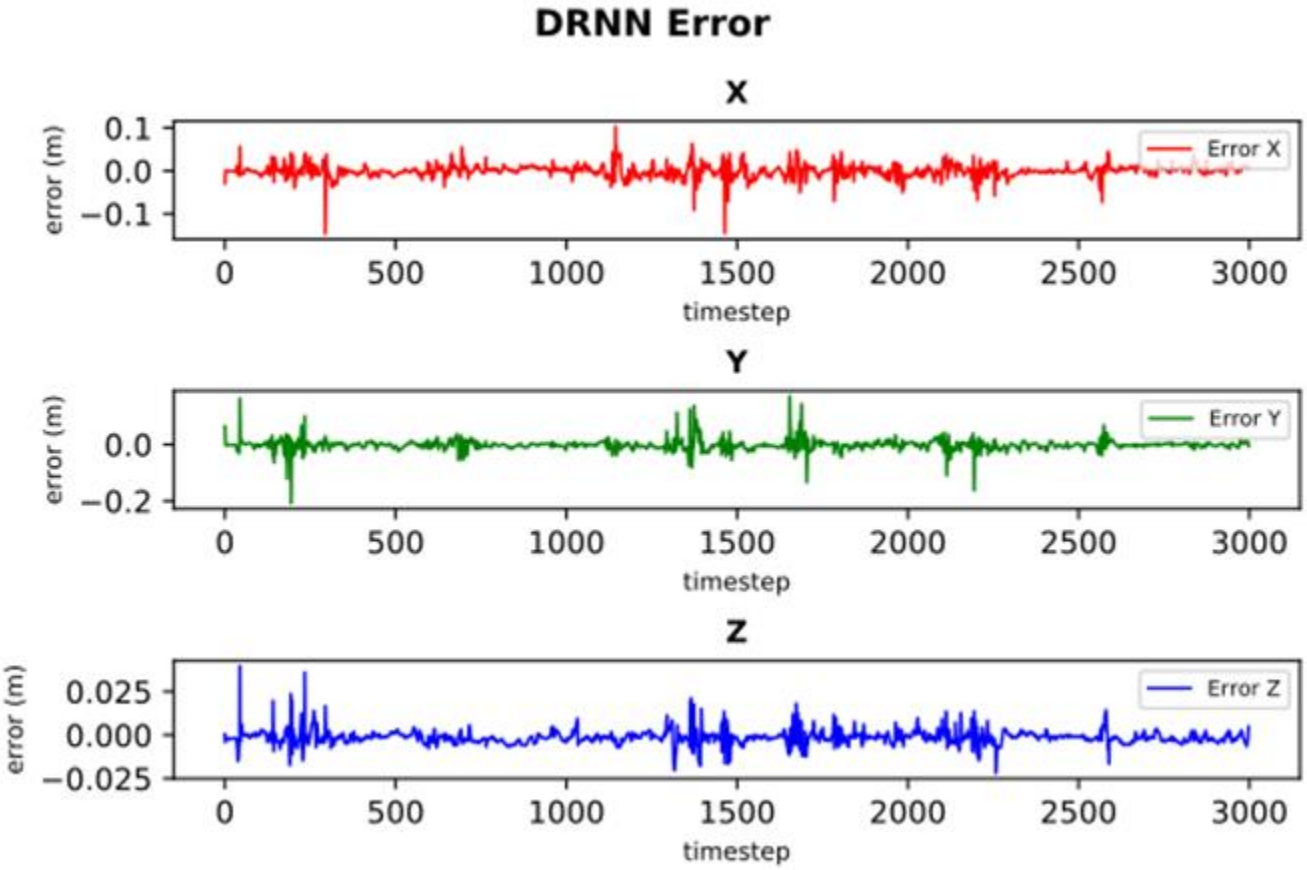
1) Acceleration of the car from IMU (a_x, a_y, a_z),
2) Angular velocity of the car from IMU $(\omega_{roll}, \omega_{pitch}, \omega_{yaw})$,
3) Previous estimated velocity and orientation $(\hat{\mathbf{v}}, \hat{\mathbf{q}})$,
4) Control signals (brake, throttle and steer).

3 outputs

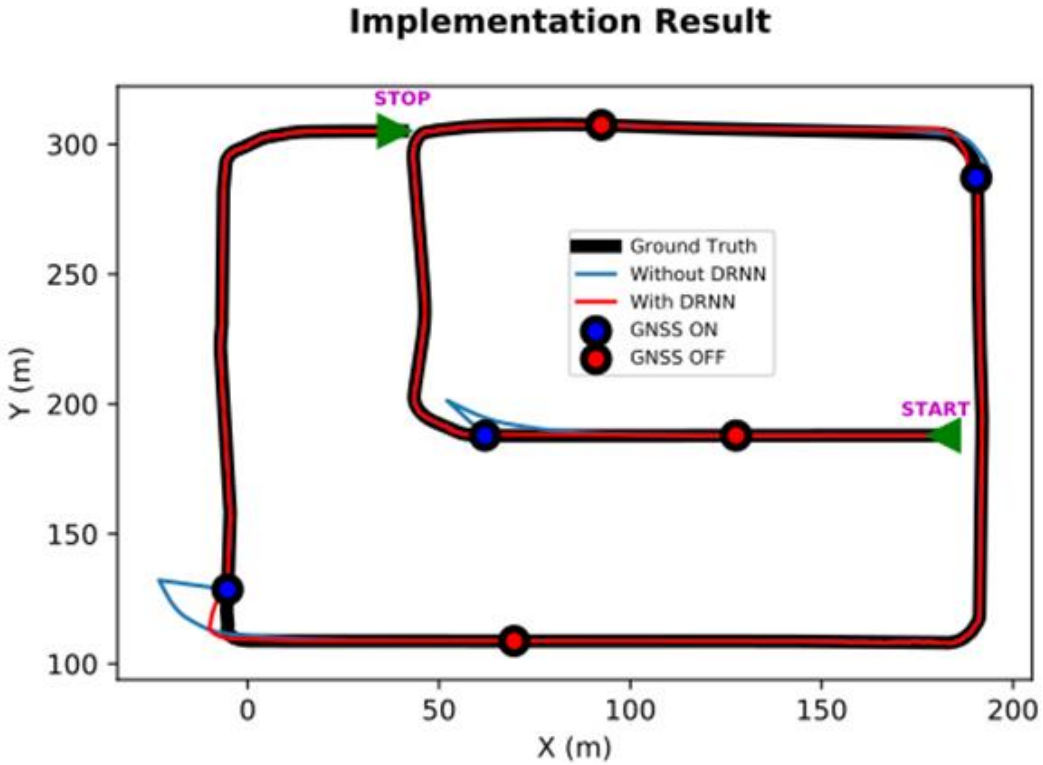
Car's displacement $(\Delta x, \Delta y, \Delta z)$



System Design: Training Results



Implementation in CARLA Simulator



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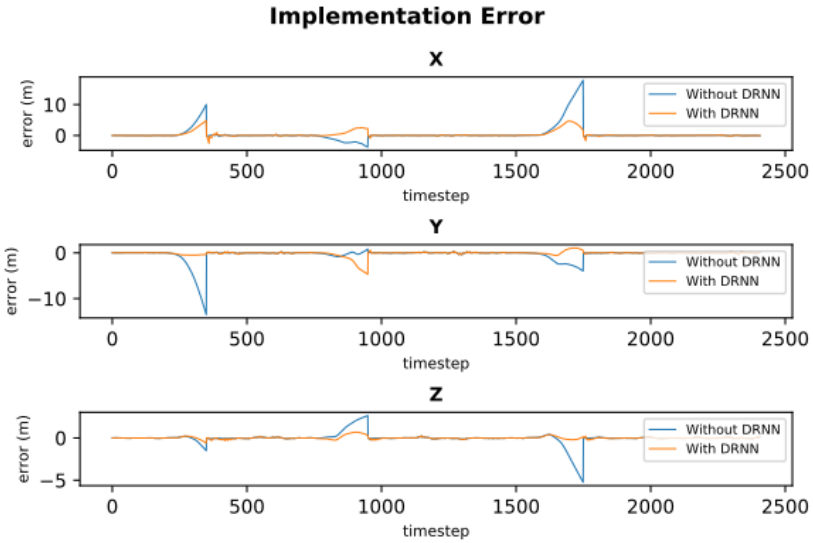

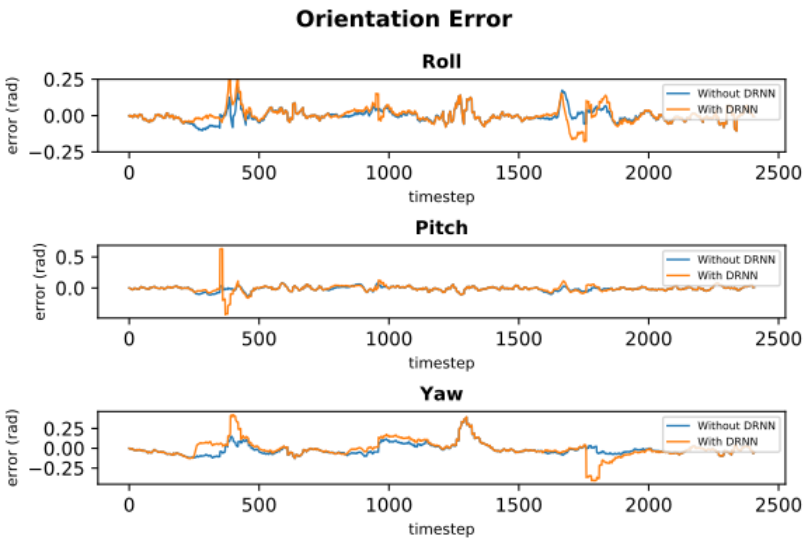

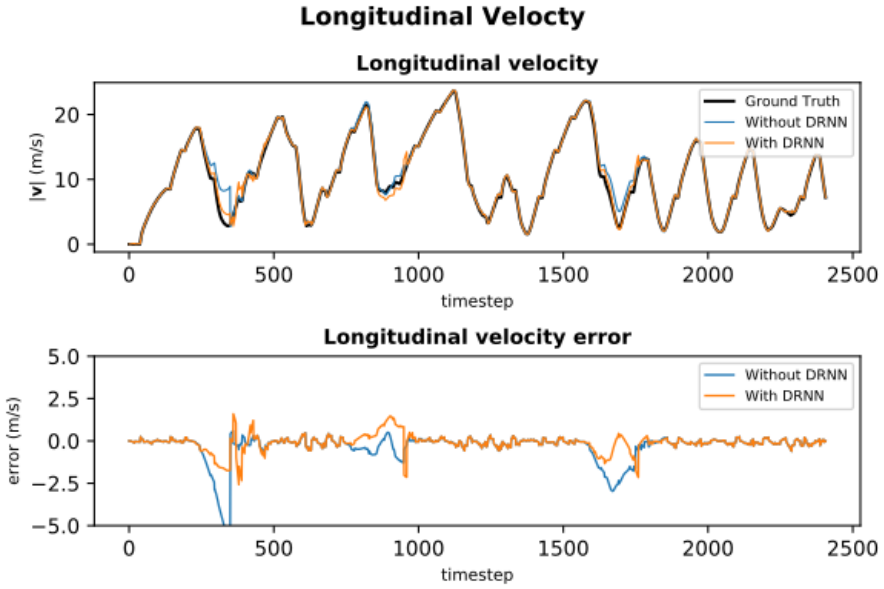

Conclusion & Future Work

Conclusion

DRNN has proven to increase the reliability of the localization system by providing correction in the event of GNSS disconnection.

Future Work

- Using a more complex model of neural network
- Reducing the error of velocity, by using additional sensor to measure velocity in particular
- Train the model with broader training datasets (more variation)

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