Autonomous car model

# State space formulation

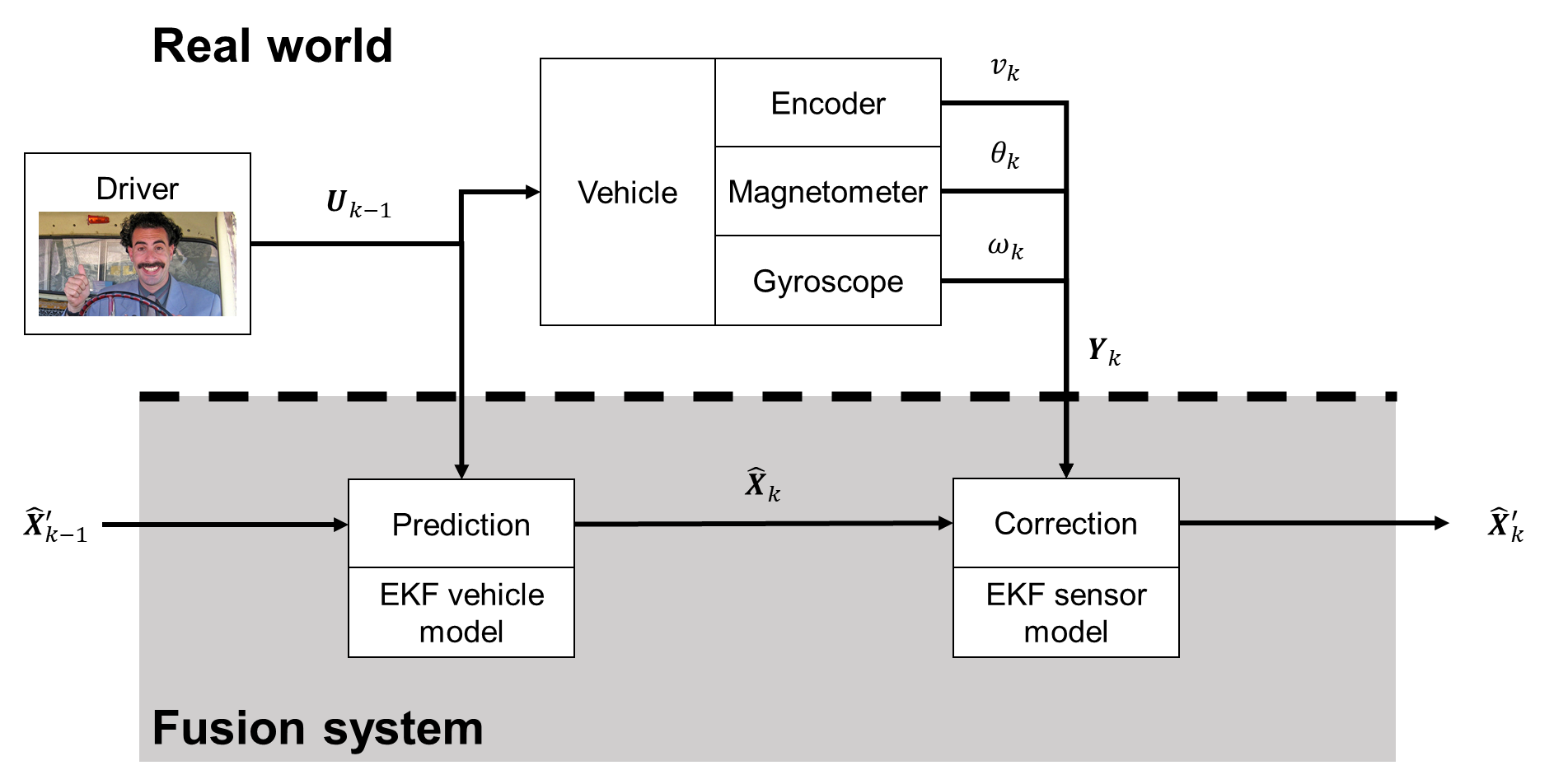
Source: ME 597c lecture, Modelling III, p. 22

This will allow prediction of state variables based on control variables, forming the basis of the physics model.

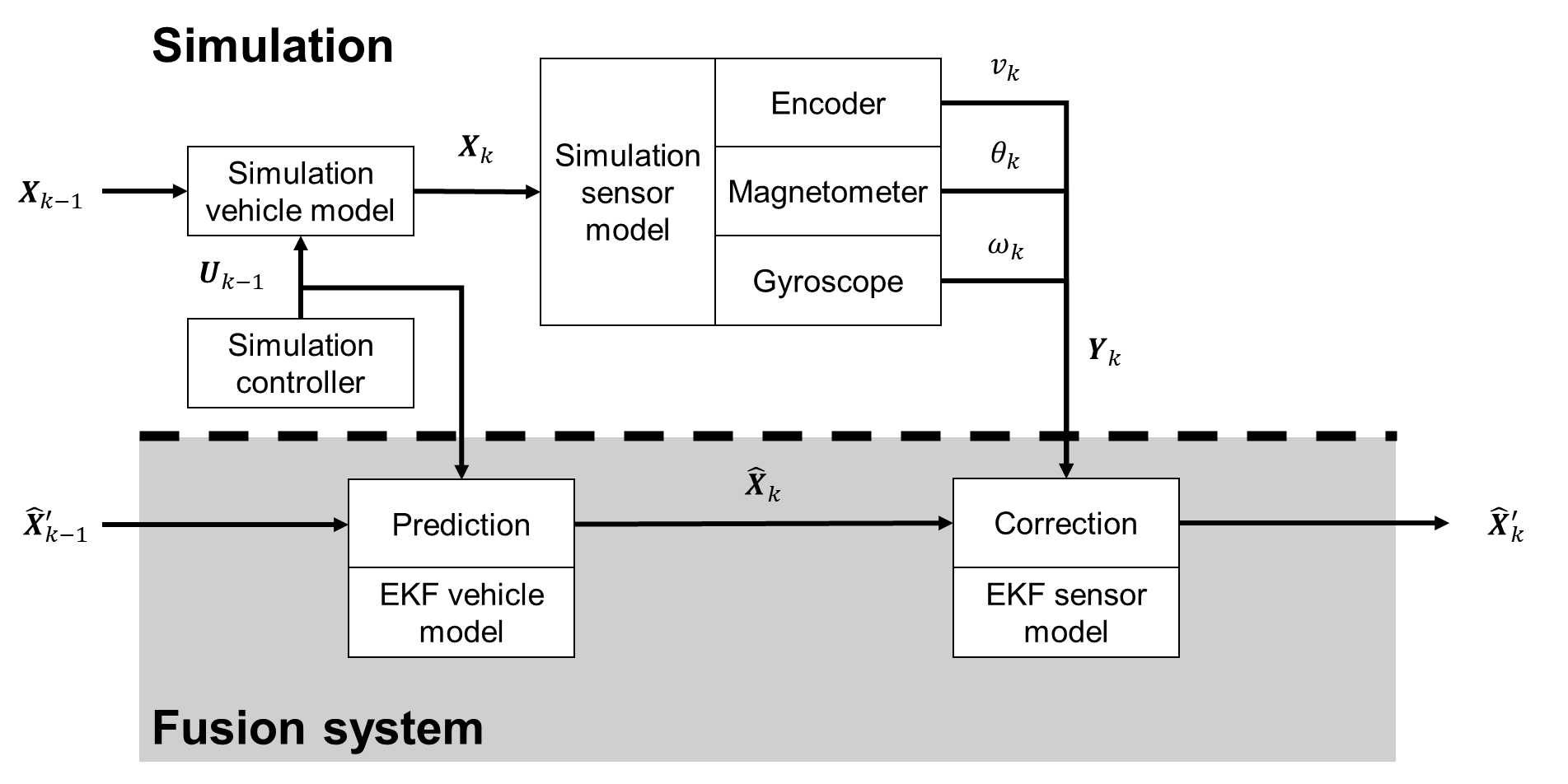
See EKF formulation section for all variable definitions.

# Simulation setup

This is how the system would work in real life:



This is how we test the EKF – by replacing the real world with a high-fidelity simulation, like CARLA:



# EKF formulation

Prediction step:

Correction step:

EKF variables and functions:

: True state

: State prediction

: Corrected state prediction

: Sensor readings

: Predicted sensor readings (based on state)

: Control input vector

: Physics/state transition model (equivalent to matrix in a KF) (do not confuse with , axle friction)

: Sensor model (equivalent to matrix in a KF)

: State covariance

: Jacobian of (not to be confused with , engine drive force)

: Jacobian of

: Physics model covariance

: Sensor model covariance

: Kalman gain matrix

Control and state variables:

: Vehicle speed [m/s]

: Rotation about z-axis, relative to x-axis [rad]

: Angular velocity about z-axis [rad/s]

: Front wheel drive torque [N-m].

: Front wheel drive force [N]

: Steering angle, (+ve = left, -ve = right) [rad]

: Steering angle rate [rad/s]

: Direction of motion for COG [rad]

: Rolling friction force for wheel ; for front wheel, for rear wheel [N]

Model constants – these need to be defined *a priori*, mostly by the design of the car:

: Frontal vehicle area [m2]

: Coefficient of drag

: Length between rear and front wheel axes [m]

: Distance between rear wheel axis and COG [m]

: Vehicle mass [kg]

: Axle coefficient of friction for wheel ; for front wheel, for rear wheel

: Wheel radius [m]

: Acceleration of gravity [m/s2]

# Derivation of angular acceleration

My working to derive in the state transition model: