ECE 486: Control Systems

Lecture 1: Introduction to Control

Key Takeaways

The basic principle of feedback is to:

- Use a sensor to measure the system behavior
- Compare the measured behavior with desired behavior
- Take an action based on this comparison.

This lecture:

- Motivates the use of feedback control.
- Introduces block diagrams and basic terminology
- Summarizes the typical steps in control design

Example: Automotive Cruise Control

Objective: Use the engine throttle to track a desired speed specified by the driver

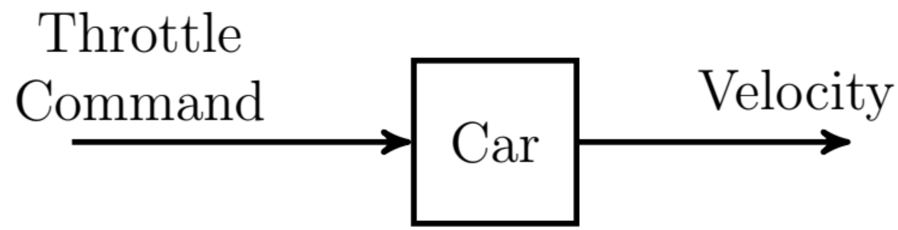
User interface

Vehicle

Block Diagrams

Systems represented by blocks with inputs/outputs

- "Hide" the dynamics
- Interconnect blocks for more complex systems

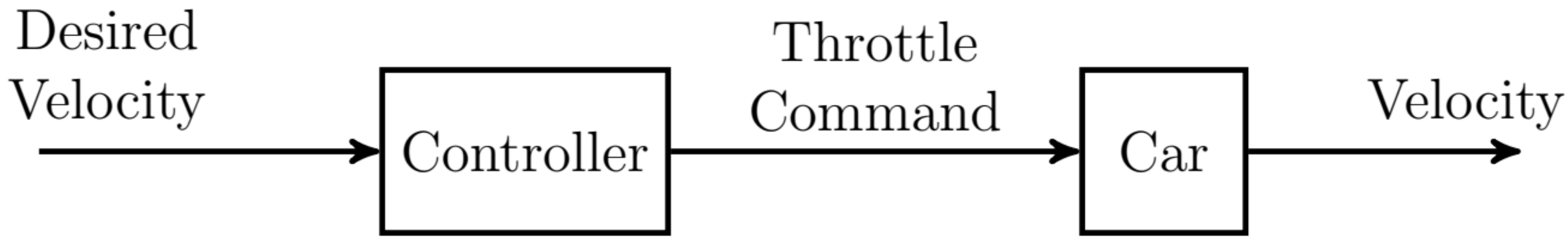


Opening the throttle allows more air into the engine and causes the car to accelerate (increasing velocity).

Open-Loop Control

- Open-loop control: Pre-compute an engine throttle angle based on the desired velocity.
- Issue: Incomplete knowledge of the car dynamics
  - Uncertain mass, e.g. different #’s of passengers
  - Varying environment conditions, e.g. hills and wind
  - Imprecise models for complex effects, e.g. engine dynamics and tire forces.

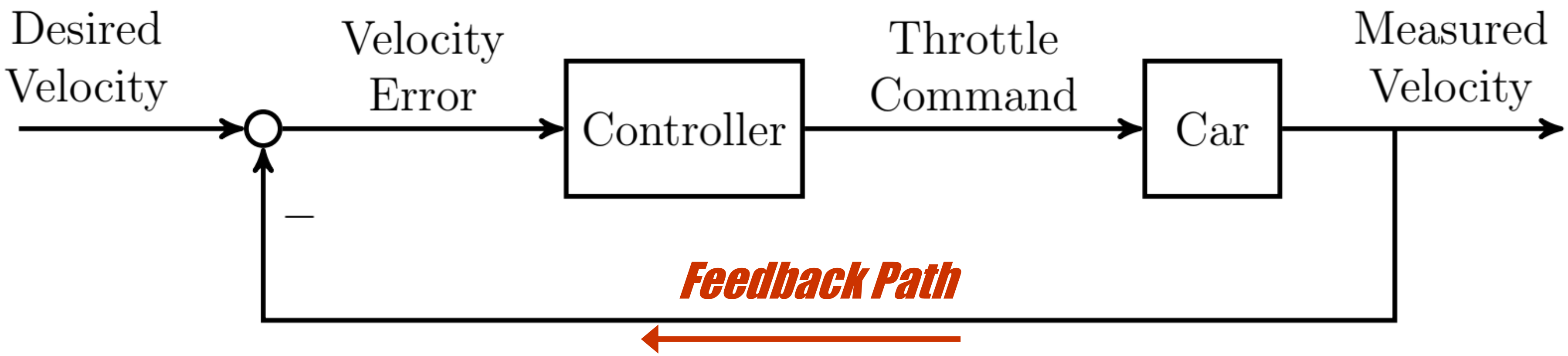
Open-loop control is generally insufficient to achieve high levels of performance in most automated systems.



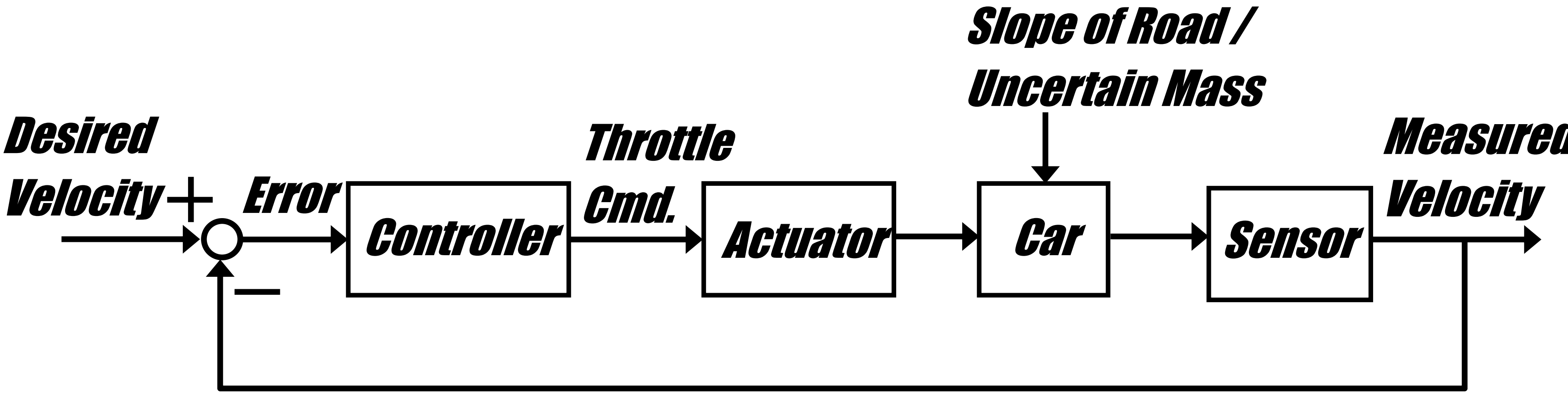
Closed-Loop (Feedback) Control

- Closed-loop control: Update the throttle command based on a measurement of the current vehicle speed.
- Controller acts based on: Error = Desired – Measured

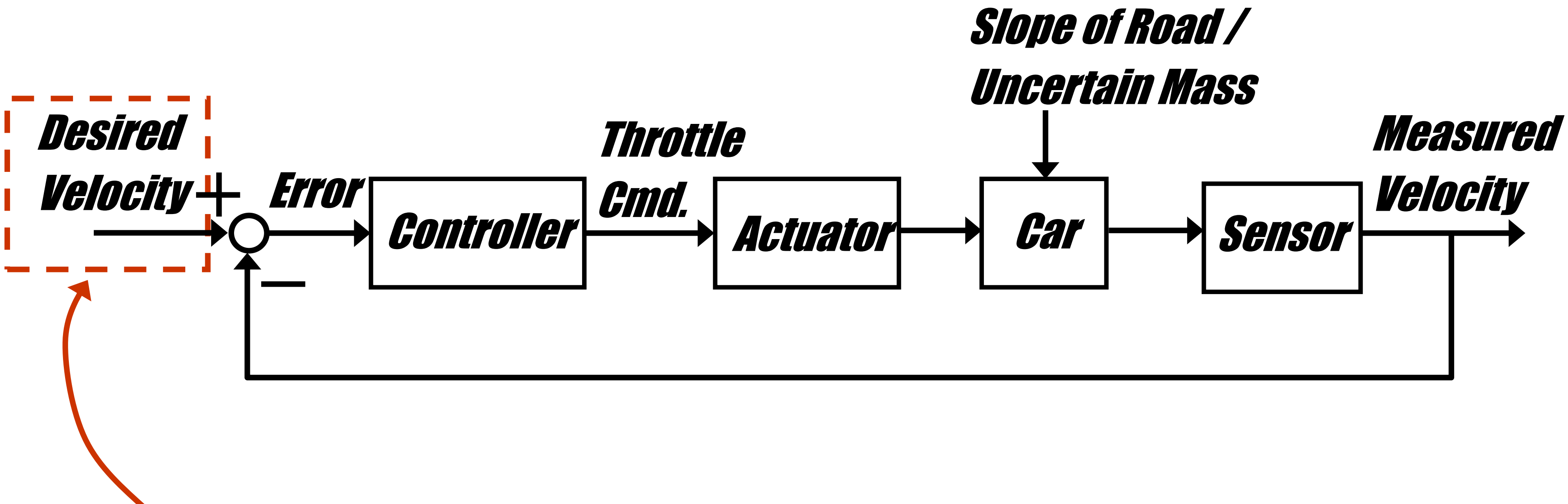
Feedback is the basic principle used to control a system with high performance despite our incomplete knowledge of the dynamics and environmental effects.



Cruise Control Block Diagram

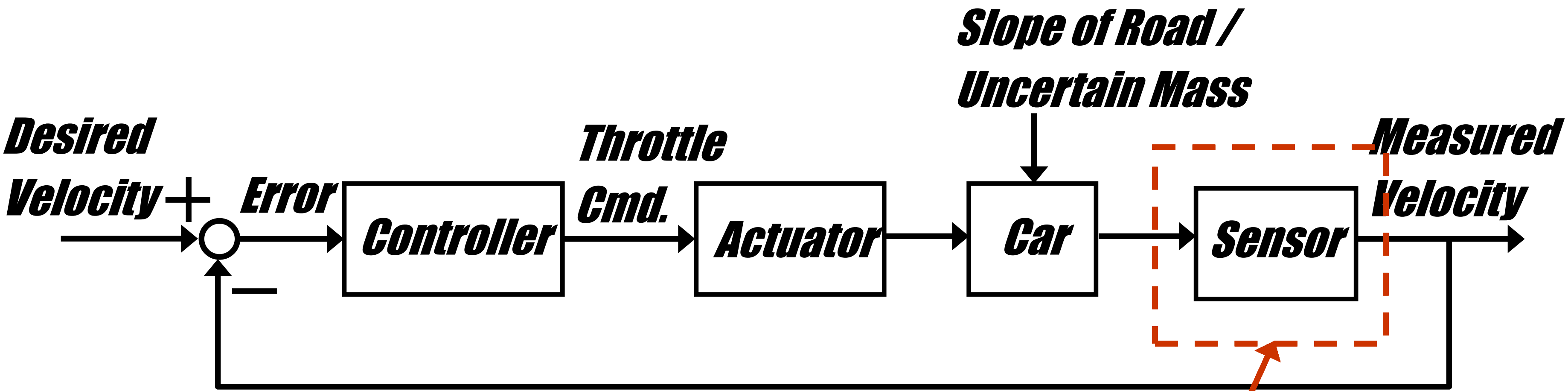


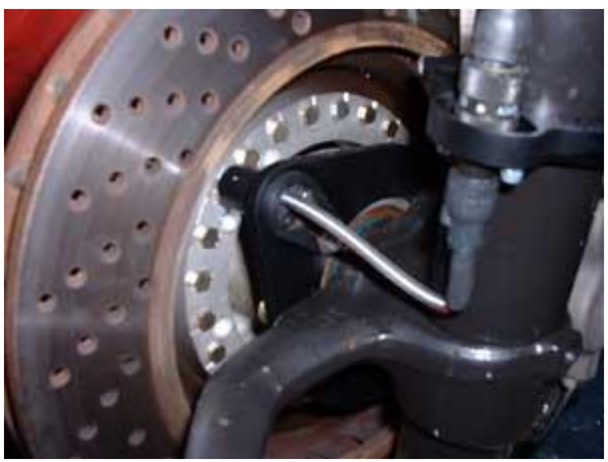
Reference Command



The reference (desired velocity) is the desired condition for the system.

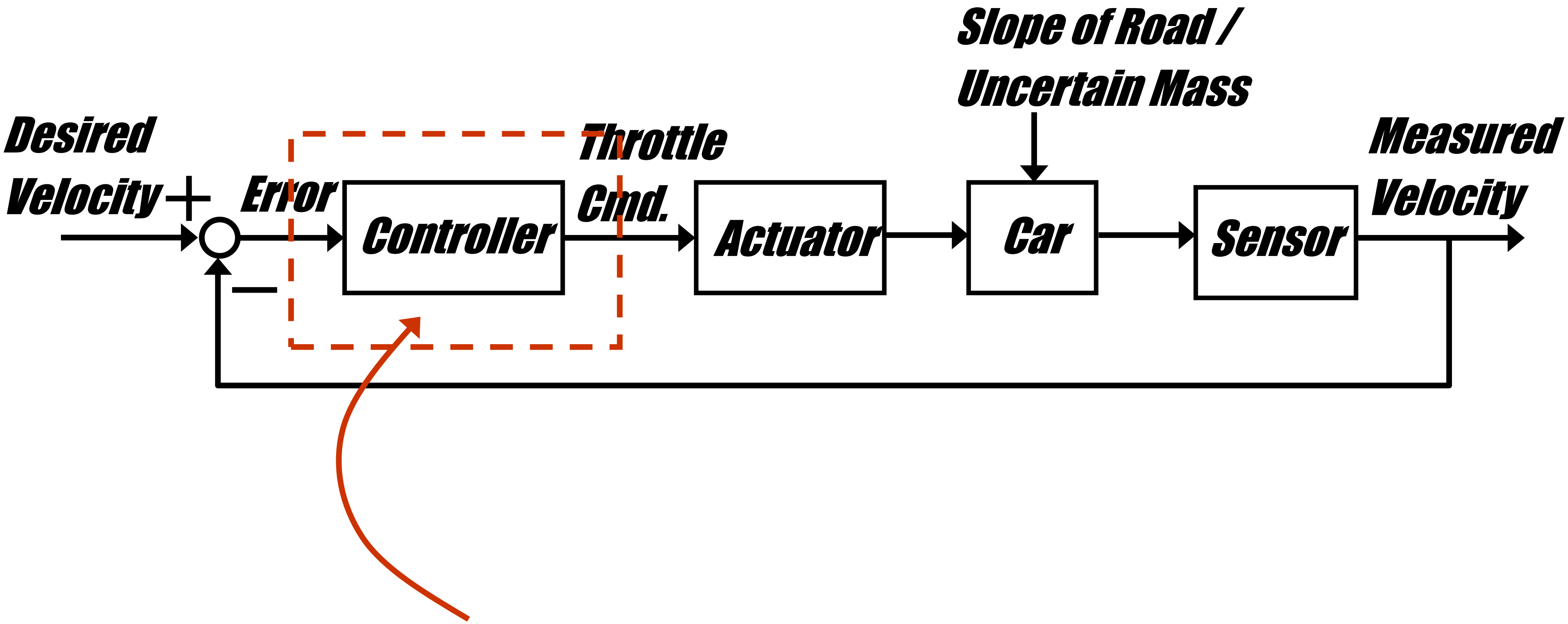
Sensor





The sensor (wheel speed sensor) is a device used to measure the behavior of the plant.

Control Algorithm

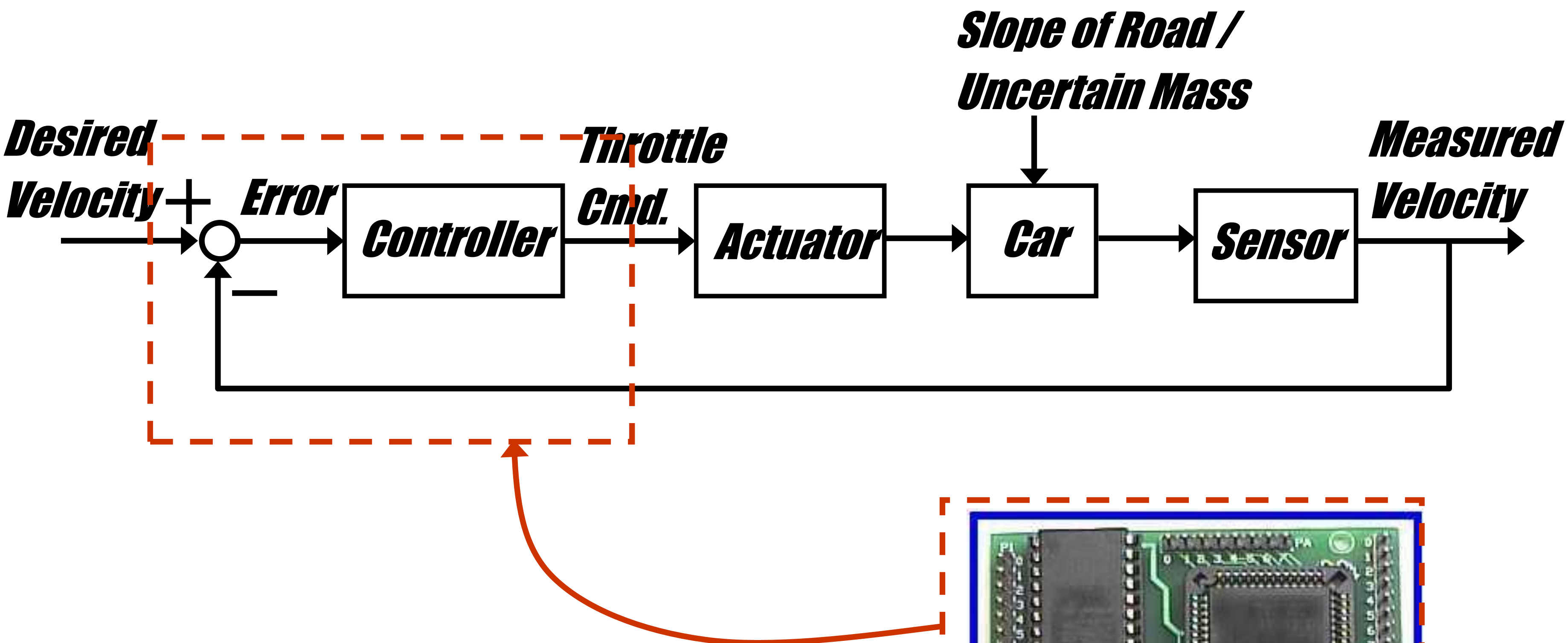


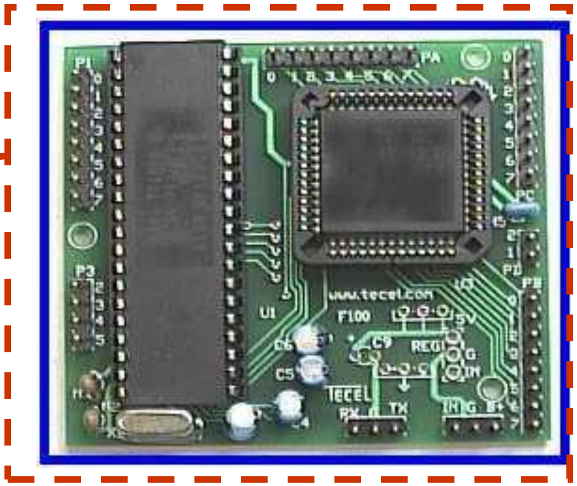
Proportional-Integral-Derivative (PID) Control

$$u(t) = k_p e(t) + k_i \int_0^t e(\tau) d\tau + k_d \frac{de(t)}{dt}$$

where e:= error and u:=throttle command

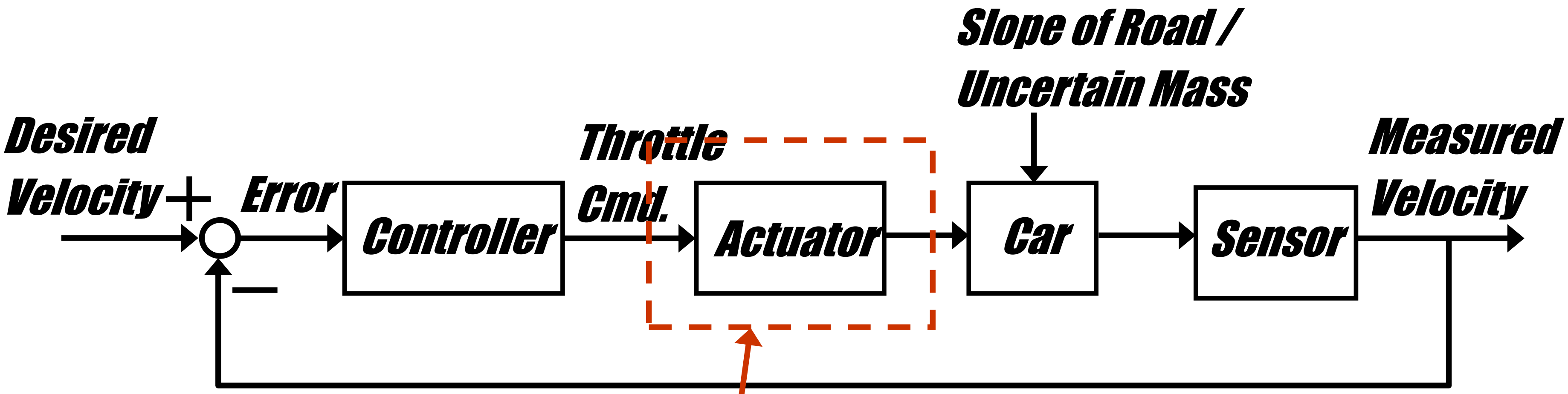
Embedded Processor





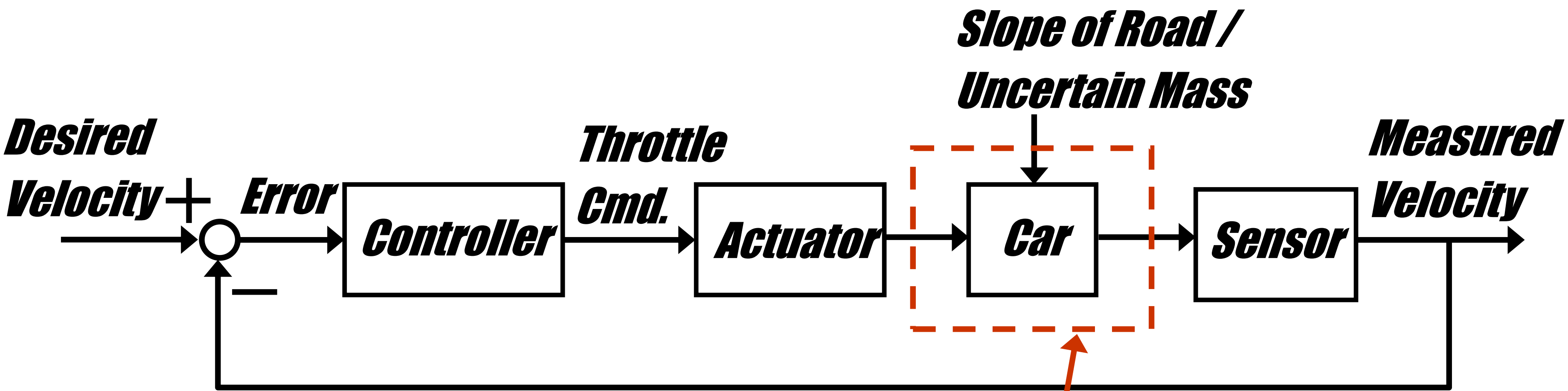
The algorithm computations are
are done on an embedded processor.

Actuator



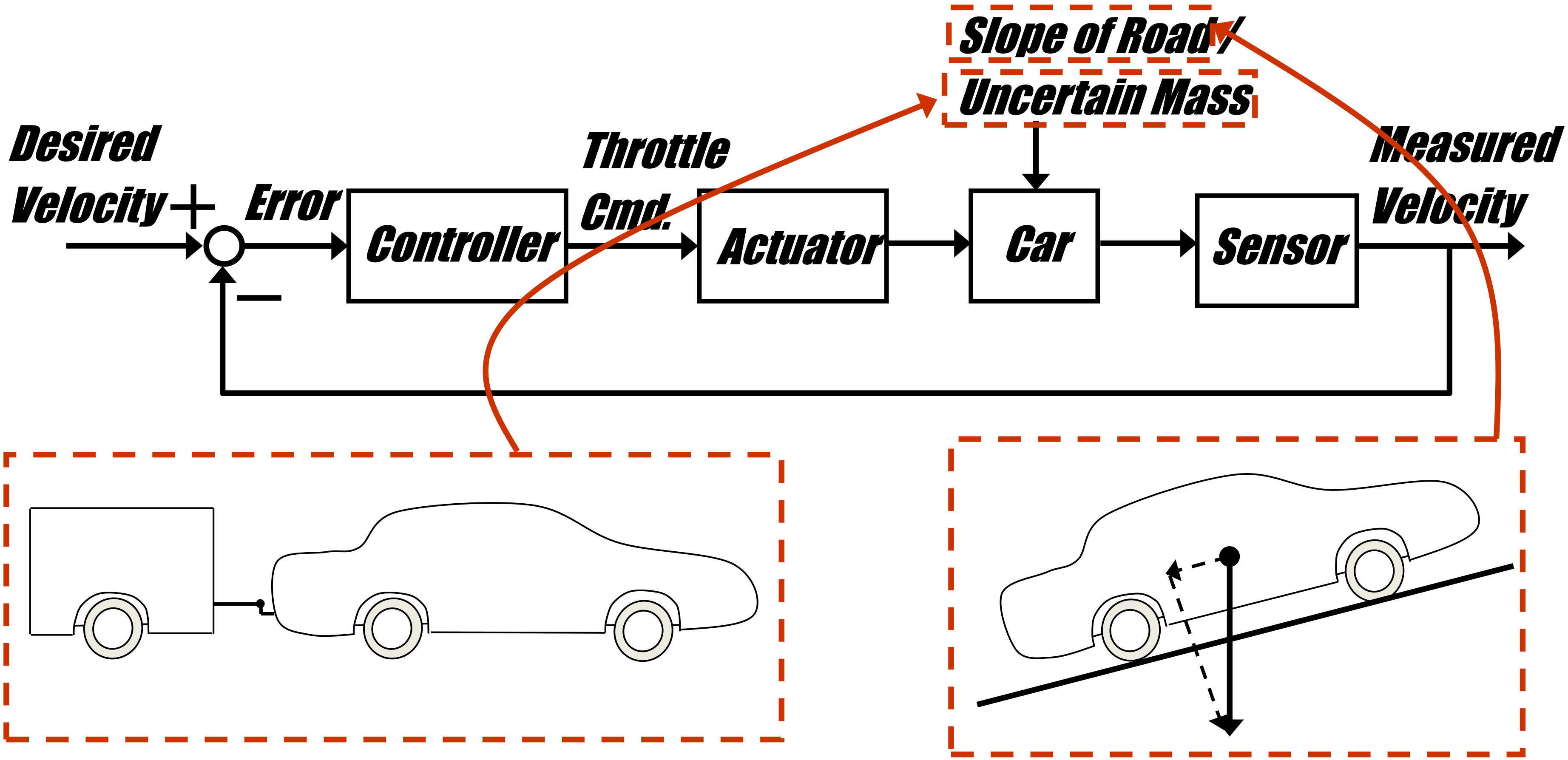
The actuator (throttle motor) is a device used to control the plant.

Plant



The plant (car) is the system being controlled.

Uncertainties / Disturbances



Design Process

1. Select the sensors and actuators
2. Model the dynamics
3. Design the control algorithm
4. Analyze and simulate the system
5. Implement the algorithm and perform tests

We will mainly focus on tasks #3 and #4 in this course.