

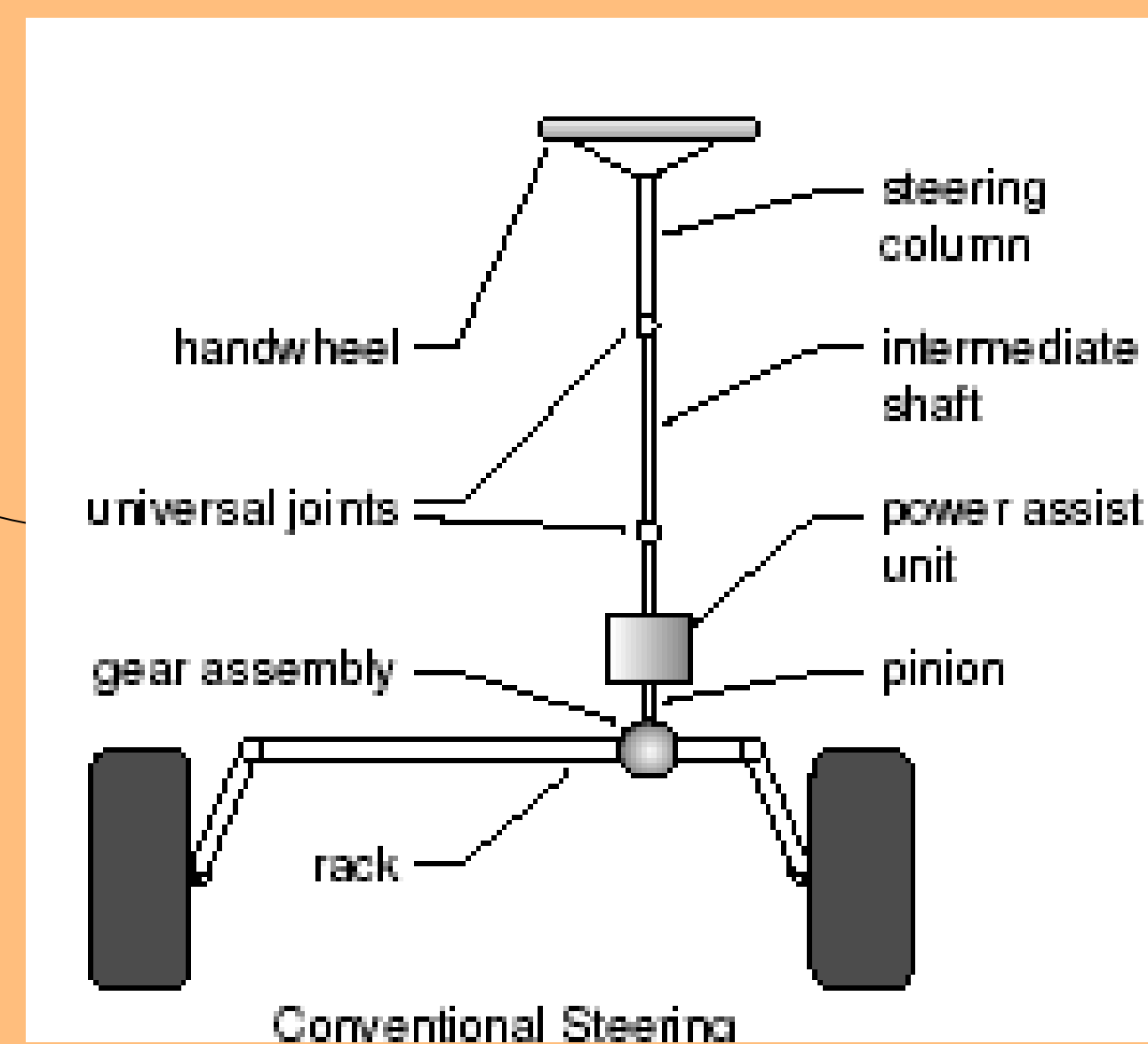
# Haptic Feedback in a Drive-By-Wire System

## What is a Drive-By-Wire System?

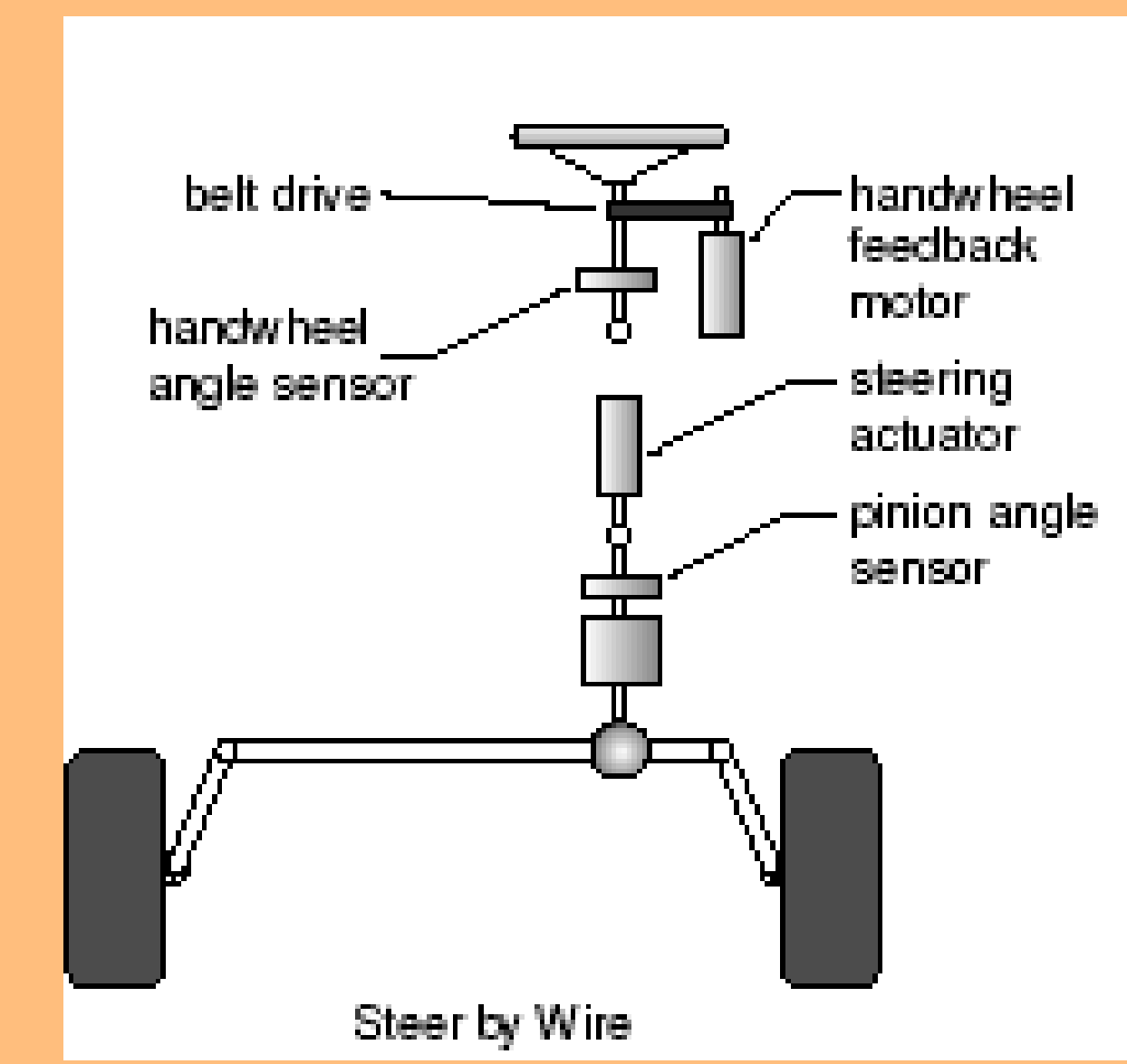


- First appeared in aviation (1972) NASA's digital Fly-By-Wire

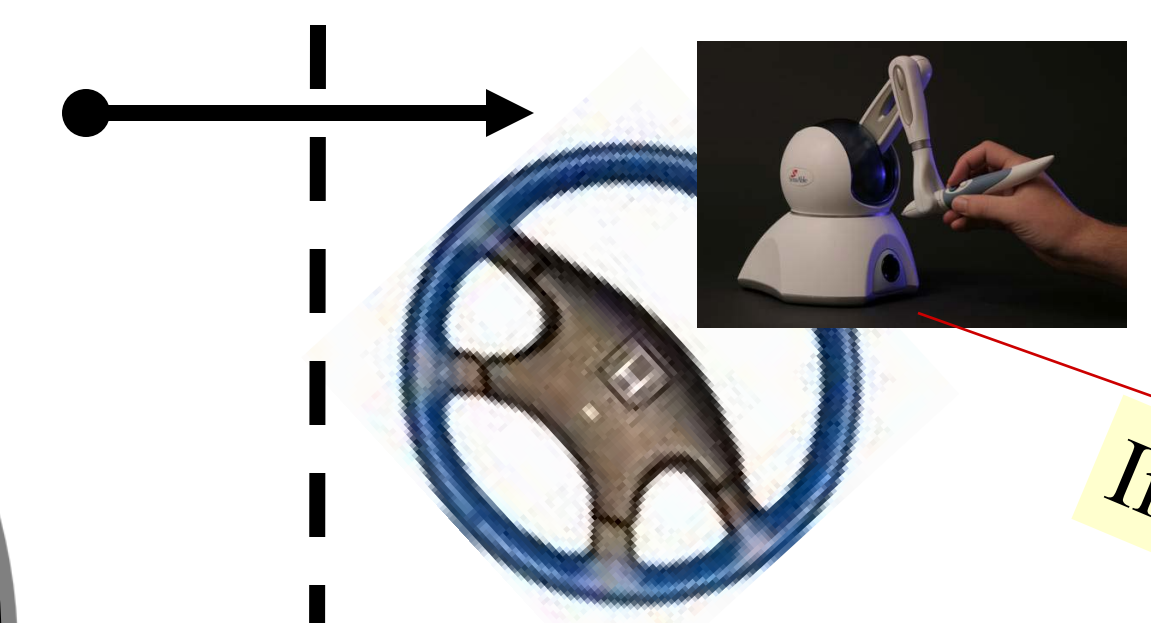
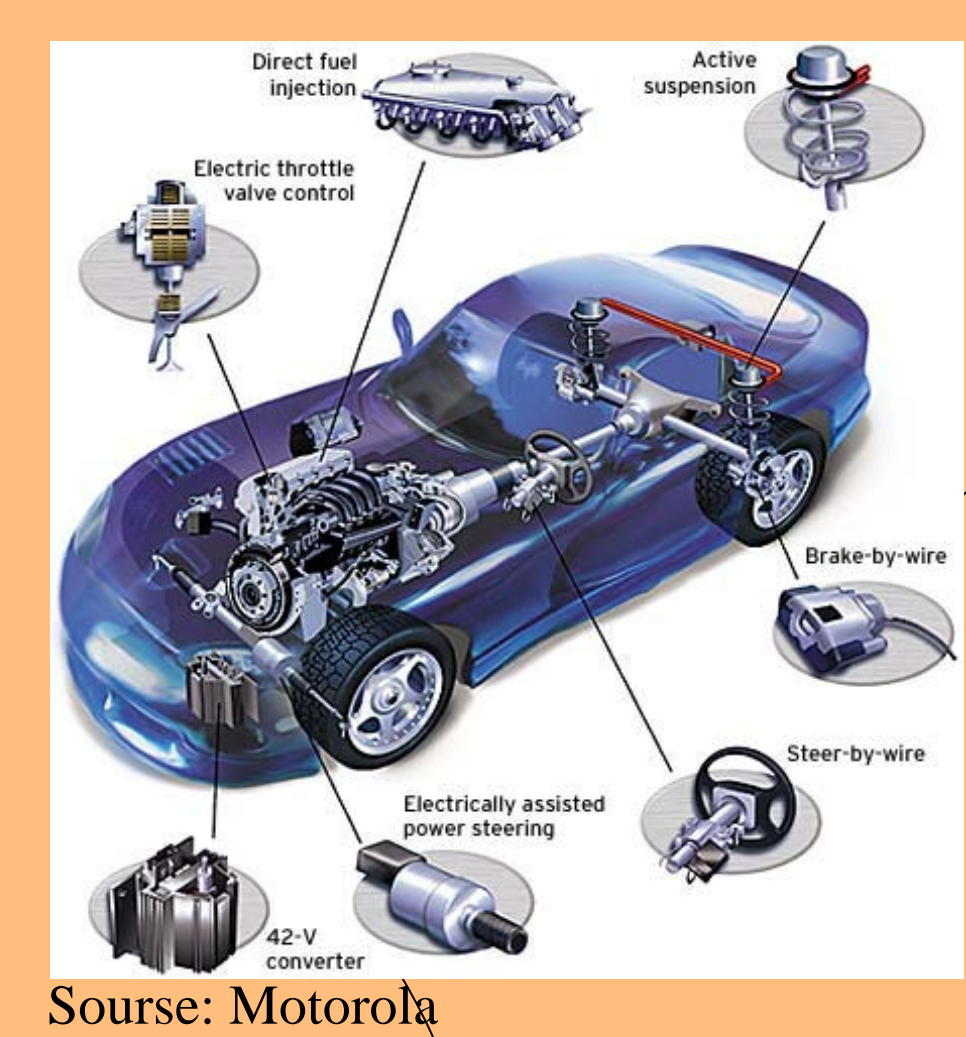
### Automotive Application



Forces are transferred from the road wheels to the steering through mechanical linkage



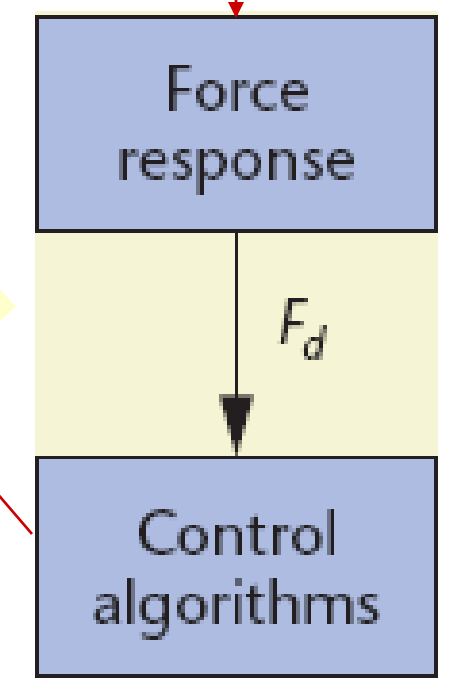
- Mechanical linkage removed
- Actuators control the road-wheel response
- Significant similarities with tele-manipulator systems.



Haptic Device User Input

Input

Feedback



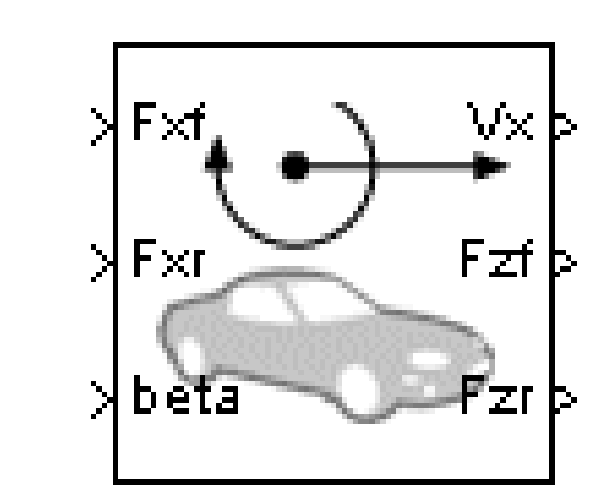
## Haptic Feedback or Simulating Road Feel

### Vehicle Dynamics Simulation Engine

- Goal to provide Driving feeling steering

We need to know.....

1. Steering angle  $\delta$
2. Aligning Moment ( $M_x$ )

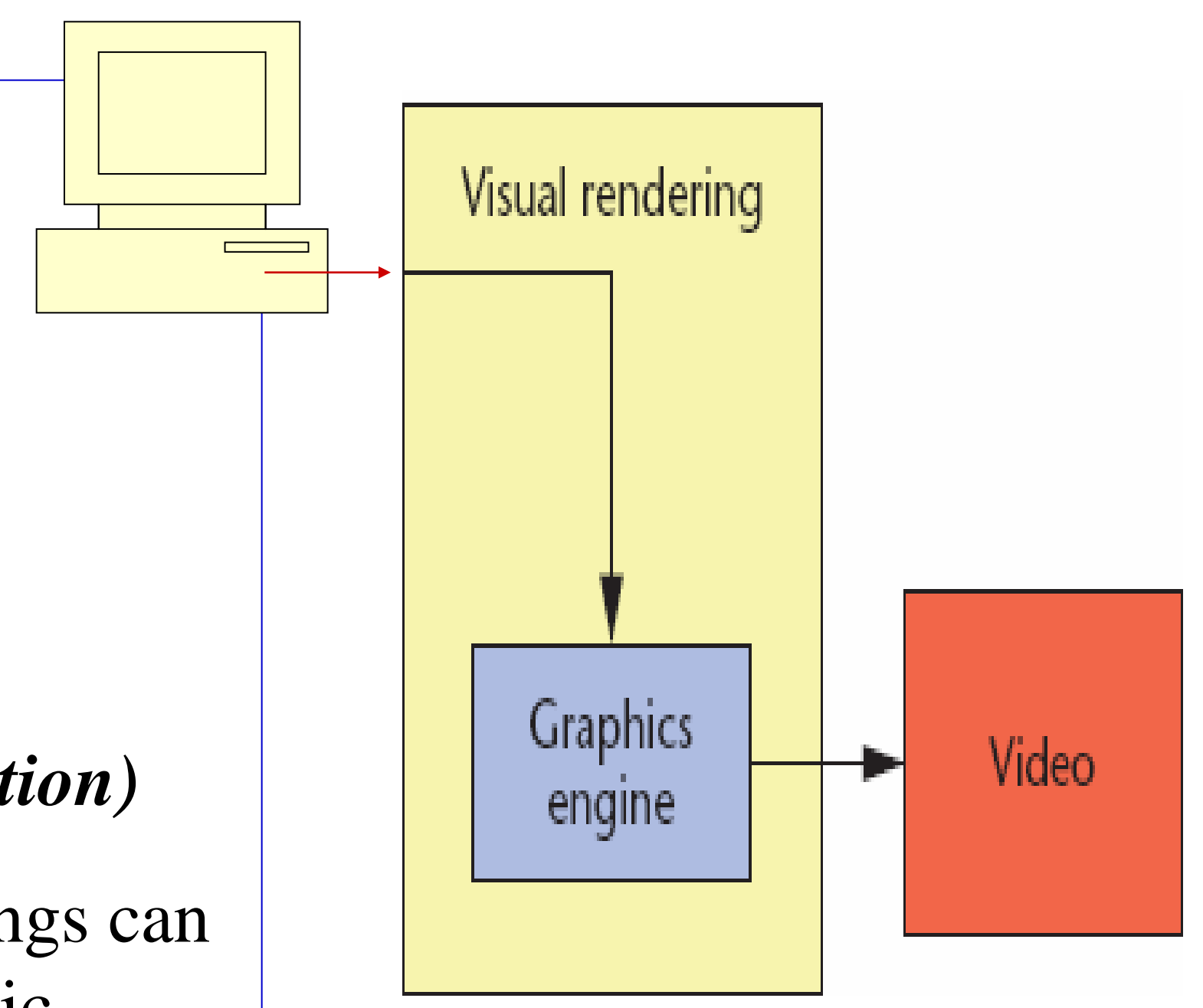


$$M_x = f(\delta, v, Tire, Suspension, Road Imperfection)$$

In a steer-by-wire system, different steering feelings can be obtained by modifying the  $\delta - M_x$  characteristic.

### Performance Measure

- calculate Root Mean Square for the deviation of the user path from the prescribed path.
- Fourier series
- Additional Measures?



### Advantages:

- Vehicle Safety
- Simplify vehicle cabin design.
- Data collected can be used for various other purposes,
  - remote driving
  - automatic lane detection
- Driving simulators for training purposes



### Challenges and future research:

- Since steering is the primary control mechanism **Fidelity of the system** {"Right Feel"} is very important.
- Accurate estimates of position, velocity and acceleration.
  - traditional steering angle sensors, potentiometers
  - high resolution sensors, encoders required.
  - high frequency noise cause errors in measurements.