CDSL
CONTROL & DYNAMIC SYSTEMS
LABORATORY

제어 및 동역학 연구실

Founder of Control & Dynamic Control Lab.

Ph.D at UCLA (1985)

Associate Professor at Texas Tech University

Prof. Jin Heon Seo

Director of Engineering Research Center for Advanced Control and Instrument

Ph.D at SNU (2000)

Prof. Hyungbo Shim

Overview

Dynamic system

mechanical, electrical, chemical, biological, sociological... or
linear/nonlinear
time invariant / varying
continuous / discrete / hybrid
stochastic / deterministic

Math. Model →

input → **Dynamic system** → output
Controller / Algorithm
Goal / Constraints

Math. Proof →
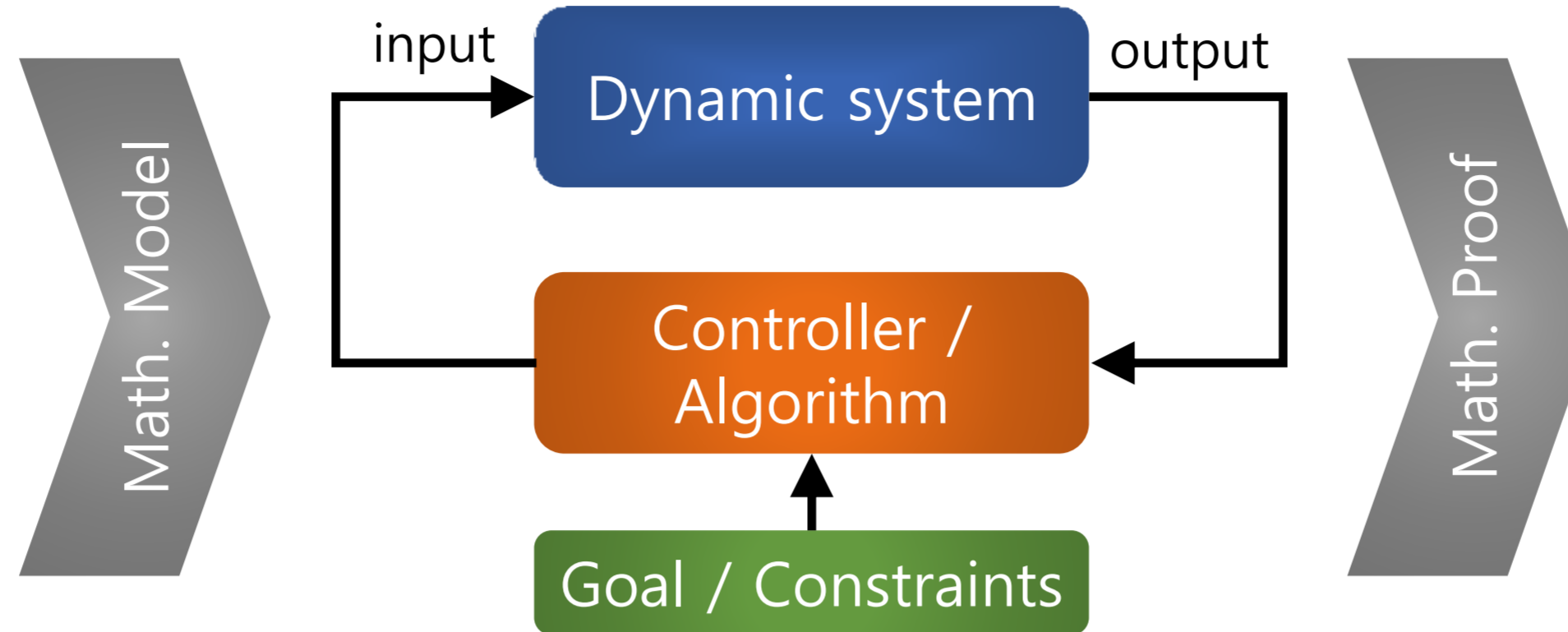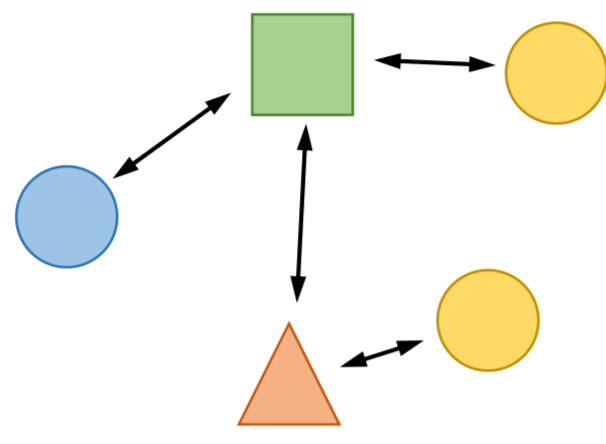
Goal

stabilization, optimization,...

Constraints

uncertainty, noise, disturbance, saturation, communication rate, energy, time, network,...
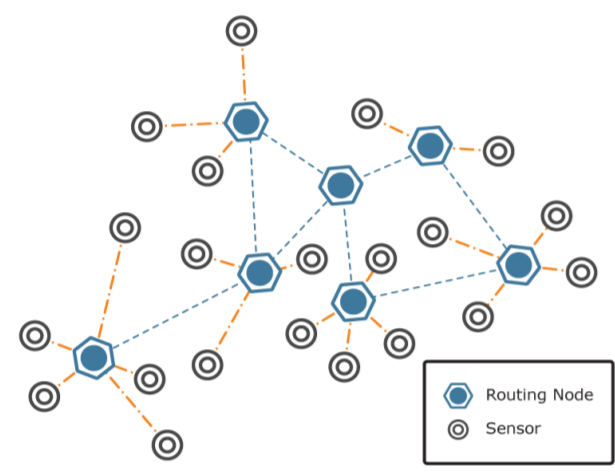
Research Topics

Consensus and Synchronization

- Multiple agents interact through communication topology

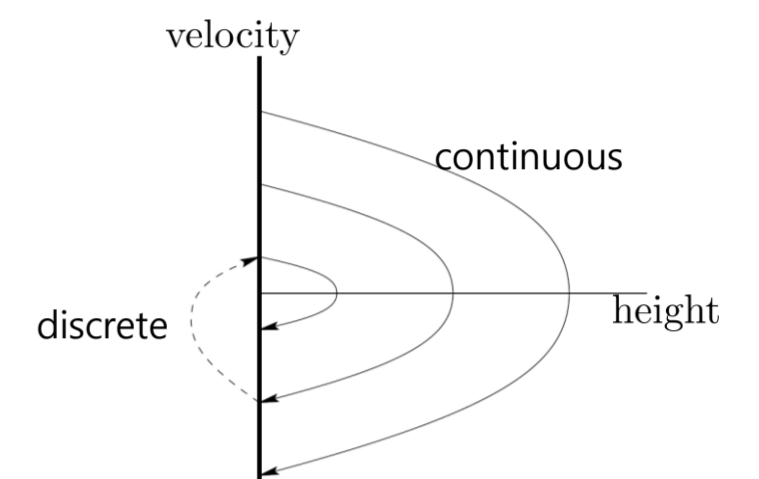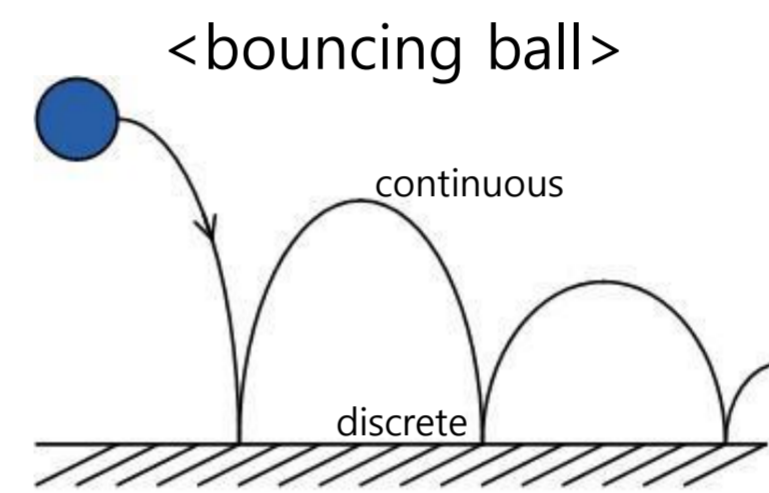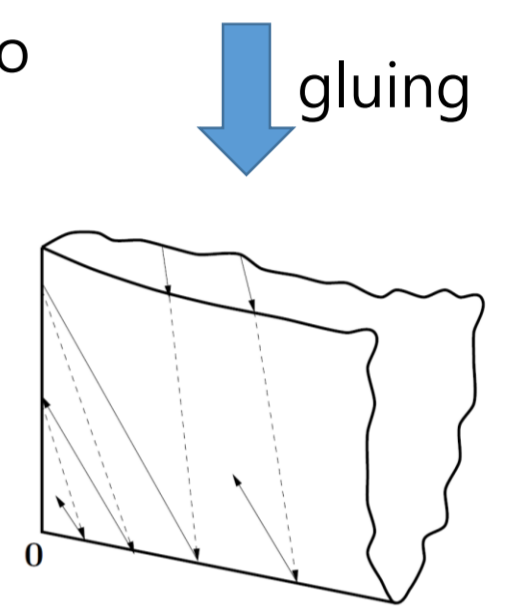- Design **local control law** to achieve common **global objective**

<Sensor Network>   <Vehicle Platooning>   <Power Network>

Hybrid System

- continuous trajectory and discrete transition

<bouncing ball>
continuous
discrete

velocity
continuous
discrete
height

- **Gluing a domain** eliminates discrete transitions to allow for easy analysis of hybrid system.

gluing

$M_2 \quad \dot{x} = F_2(x)$
∂M_2
$\frac{M_1 \cup M_2}{\partial M_1 \simeq \partial M_2}$
$\partial M_1 \quad R$
$M_1 \quad \dot{x} = F_1(x)$
$\widetilde{M} \quad \dot{x} = \widetilde{F}(x)$
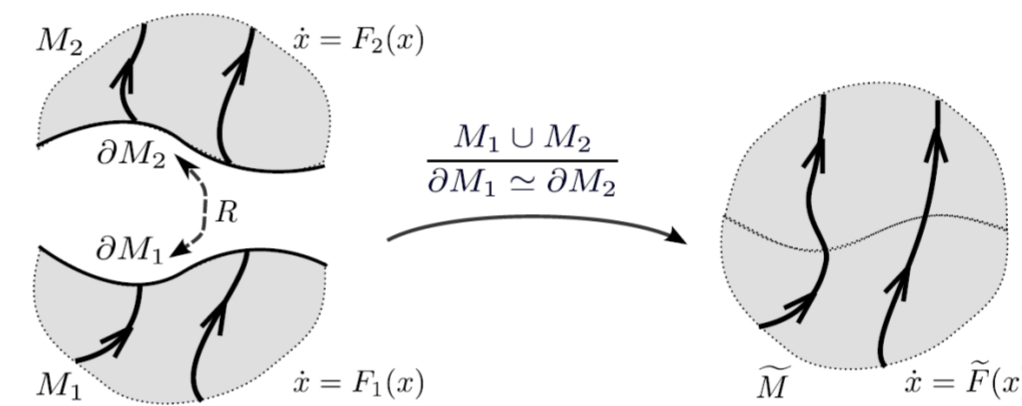
Security of Cyber Physical Systems

- **CPS**: Integration of control, communication, and computation

<Drone>   <Smart car>
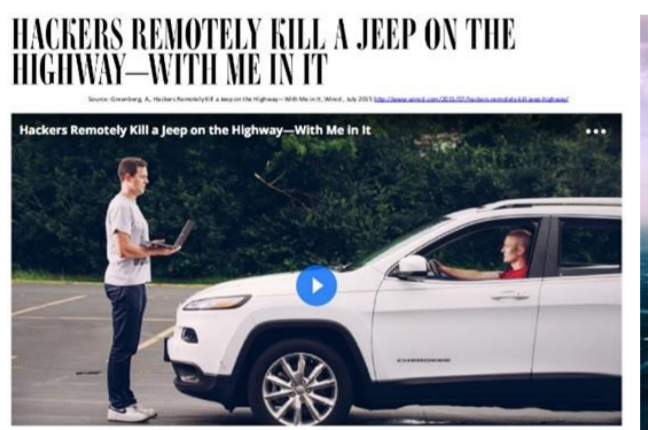
- **Security of CPS** is closely related to human life

<Spoofing attack>   <Replay attack>

- **Security of CPS**
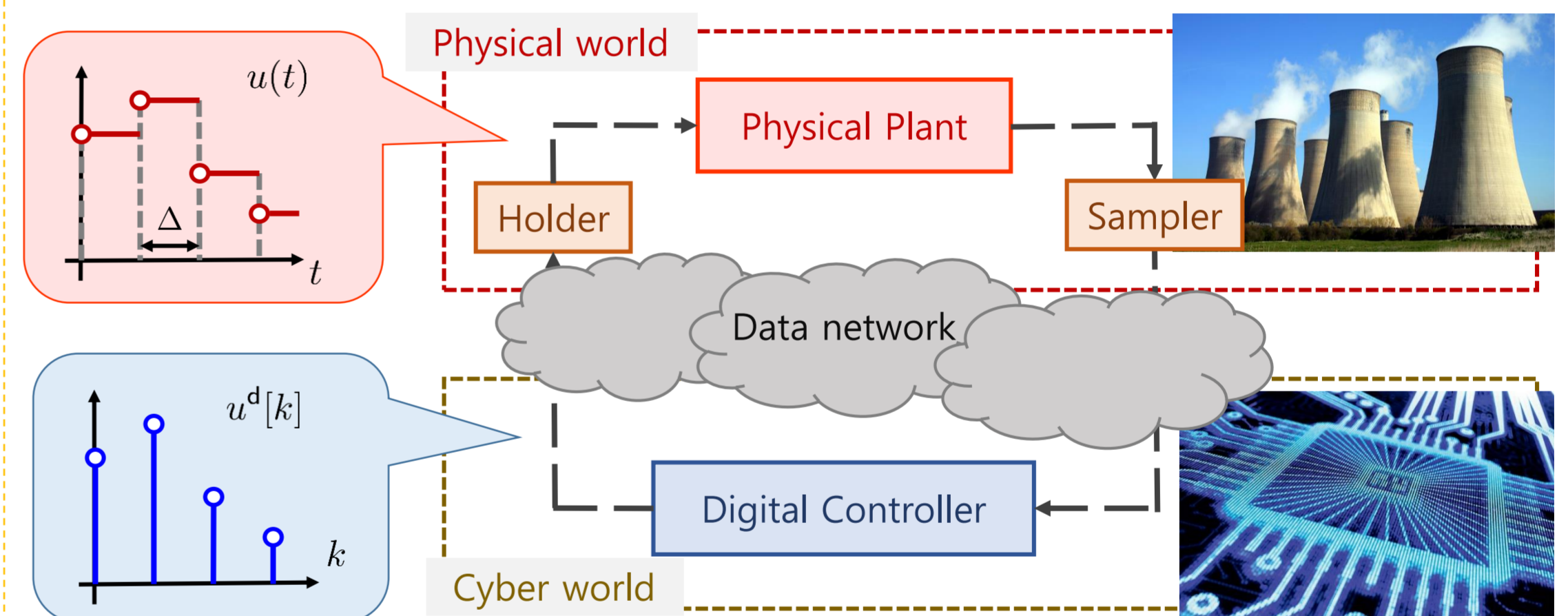
- Attack resilient system
  - Resilient estimation
  - Multi-rate sampling
  - Disturbance rejection
  - Watermark Injection

- New vulnerability of CPS
  - Zero-dynamics attack
  - Zero-stealthy attack
  - Robust zero-dynamics attack

Control Theory for Cyber-Physical Systems

- Modern control systems often consist of physical & cyber components.

Physical world
$u(t)$
Δ
t
Physical Plant
Holder
Sampler
Data network
$u^d[k]$
k
Digital Controller
Cyber world

- "Cyber-Physical Systems" = naturally **sampled-data** systems
- Advanced issues beyond continuous-time systems: additional discrete-time zeros, zero assignment, inter-sample behaviors...

Vehicle Control

- **Model Predictive Control for Path Stabilization**
For reference path, find the steering and acceleration command which makes smallest sum of distance error based on mathematical vehicle model

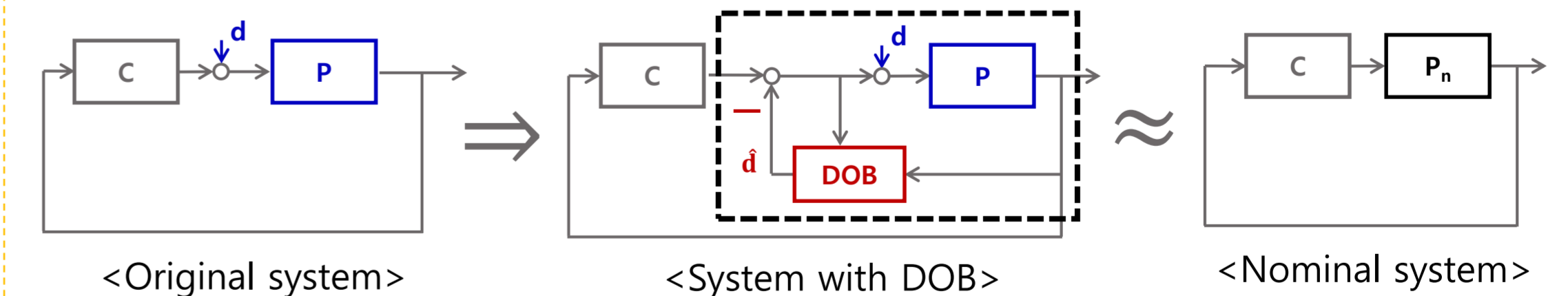Constraint violation
Candidate
Our choice

Vehicle Simulator - Carsim
Reference path
Predicted path
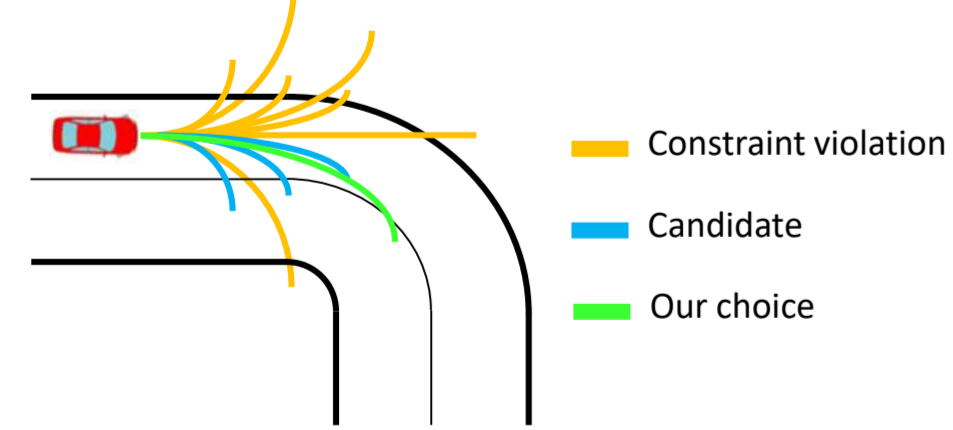
- **Obstacle Avoidance with Local Path Planning**
Using LIDAR sensor, detect object and make new path guaranteeing safety

LIDAR

Goal point
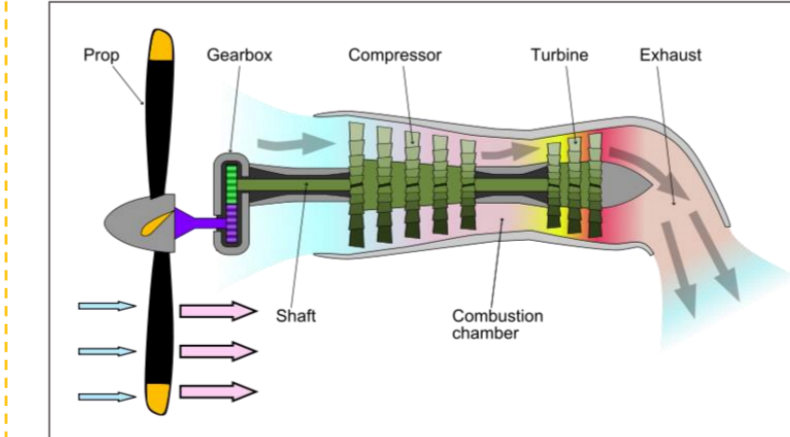Range of LIDAR
Safety region
New path
Obstacle
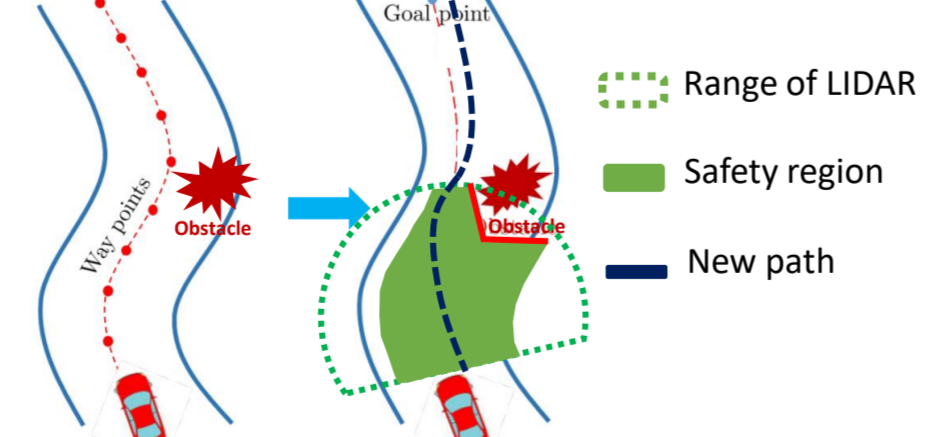
Disturbance Observer (DOB)

- **DOB** is an add-on type **robust controller.** Overall system recovers a nominal performance and suppresses the effect of disturbance.

C — d — P
<Original system>

C — d — P — DOB
<System with DOB>

C — P_n
<Nominal system>

<Rotor in drone>

Prop Gearbox Compressor Turbine Exhaust
Shaft Combustion chamber

- wind or propeller runout effect
  - speaker vibrations
  - external shock
  - aerodynamic flutter

<HDD in laptop>

Q & A

Pre CDSL
- 제어이론에 대한 강한 집착이 필요
- 수학적 소양(해석,선형)이 있으면 유리
- 교수님 면담 및 연구실 설명회 필히 참석

@ CDSL
- ~~BBQ와 가까운 연구 & 생활 공간~~
- 부드러운 인간관계 및 자유로운 학업 분위기
- 다양한 정부/기업 과제 참여 기회

Post CDSL
- 산: 삼성전자연구소, 현대자동차연구소, ...
- 학: 여러 대학의 교수님
- 연: 국방과학연구소, KAI, ...

Find out more @ www.cdsl.kr