

# **Challenges for Online Optimization of Drone Path Planning Problem**

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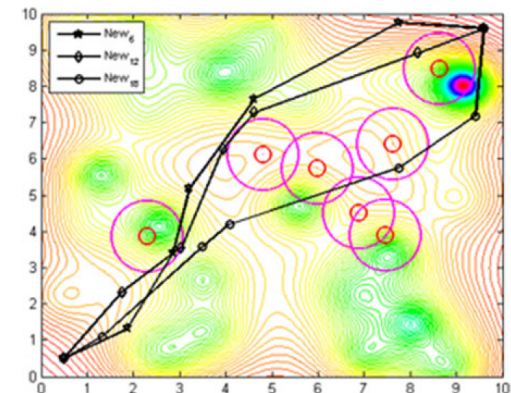
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# Acknowledgement

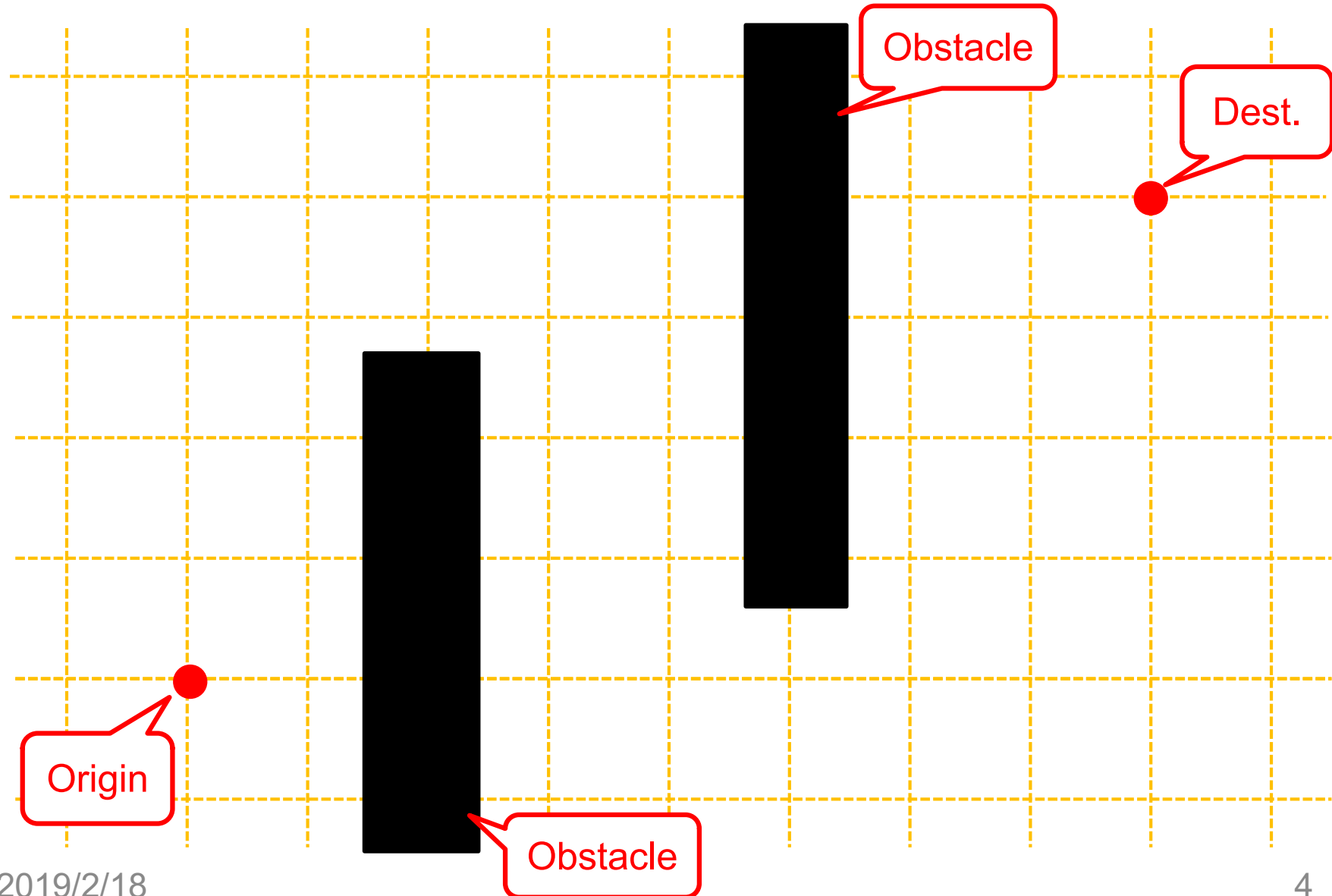
- Mr. Kento Sakurauchi, Osaka Univ., Japan
- Prof. Takateru Urakubo, Kobe Univ., Japan

# Background

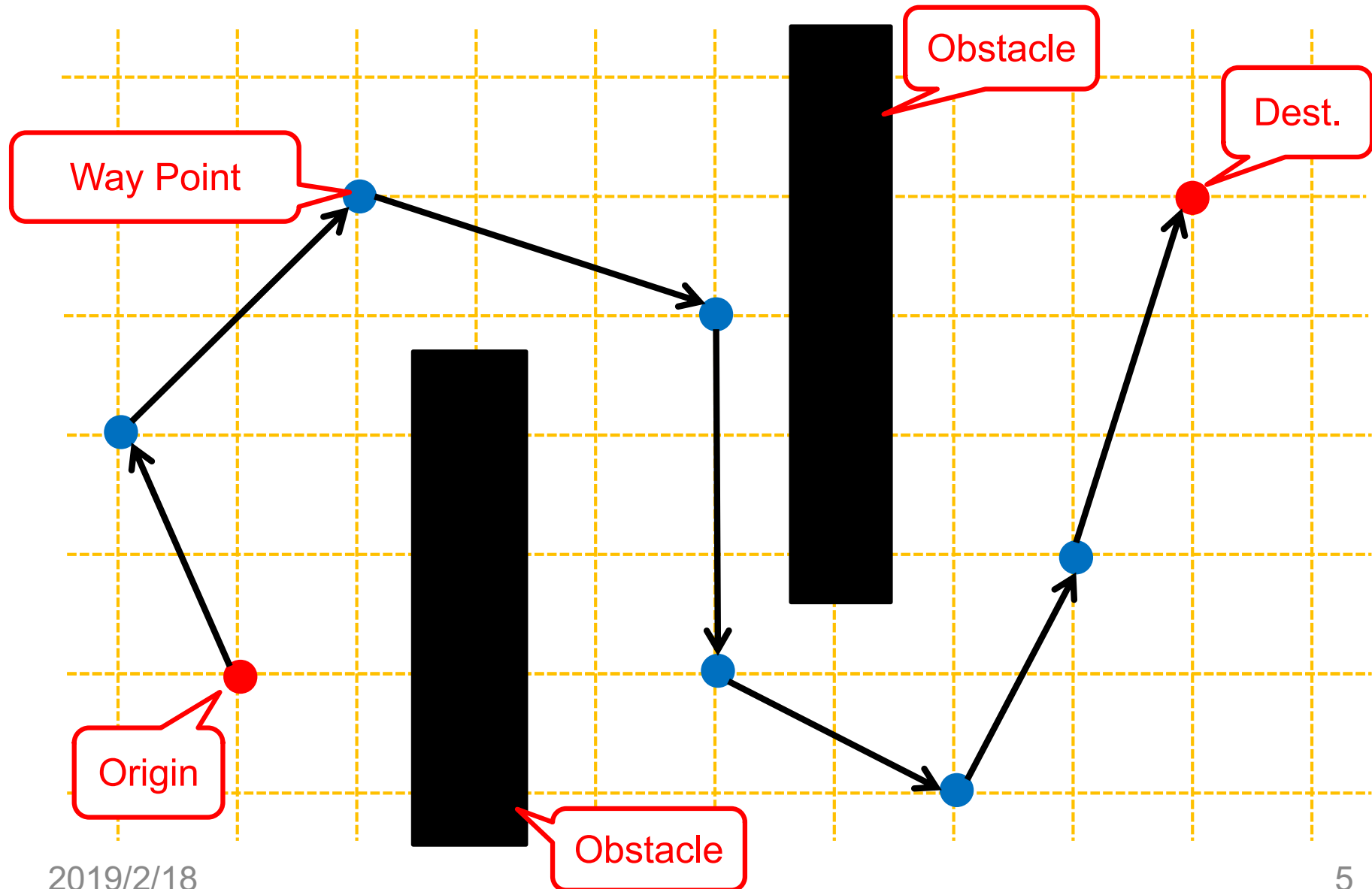
- Various drone applications
  - Delivery, monitoring, security, rescue, etc.
- Path planning for fast and safe flight
  - Putting way points to avoid obstacles between origin and destination
  - Known as difficult combinatorial optimization problem
- Challenges for online path planning
  - Solving the path planning problem during flight by on-board embedded system
  - Benefit: Adaptive flight
    - To avoid moving high-risk area (ex. windy area)
    - To update the flight plan considering the dynamics
- This work
  - Online optimization method for drone path planning
    - Co-design of algorithm and hardware



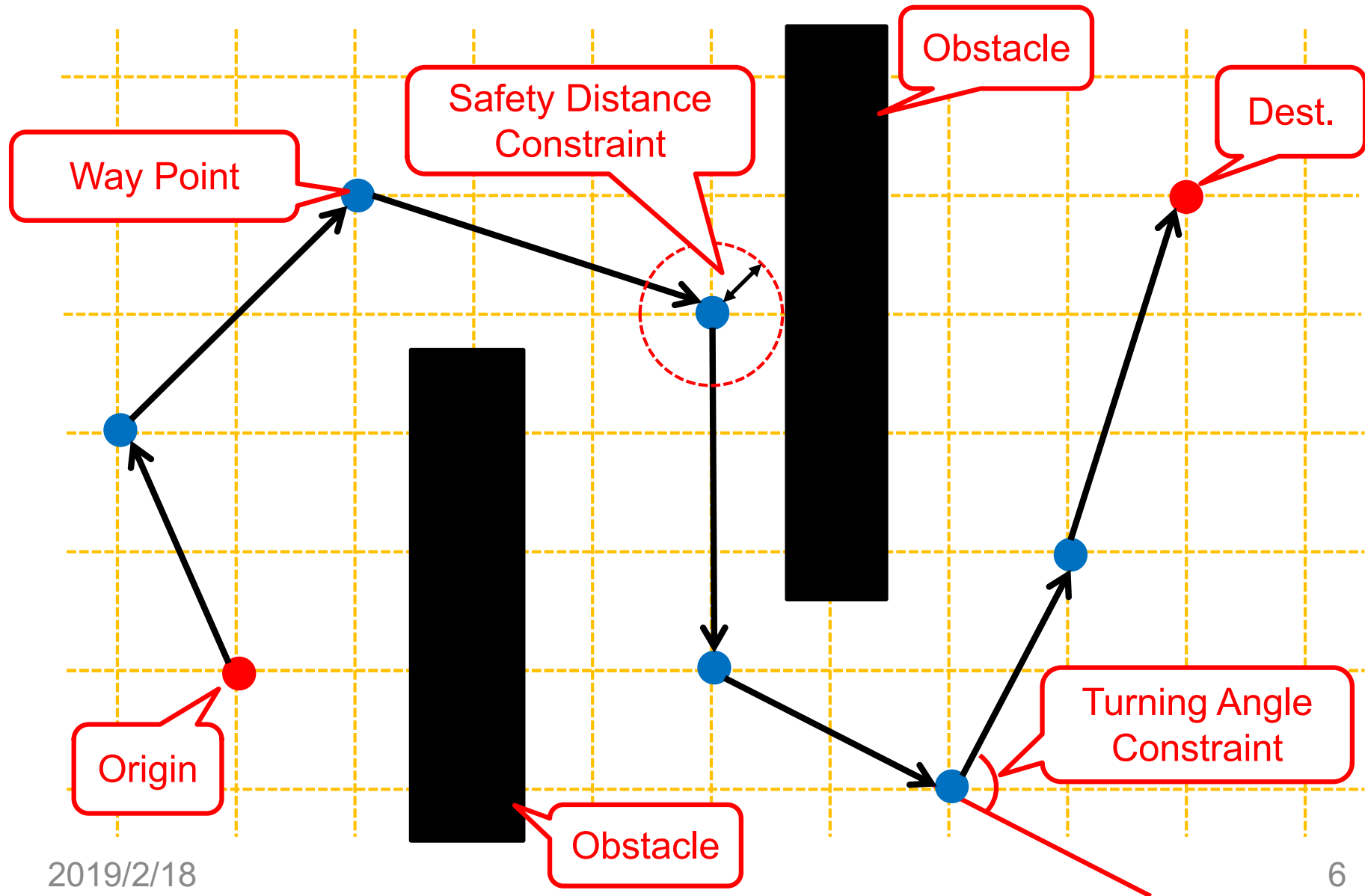
# Overview of Drone Path Planning



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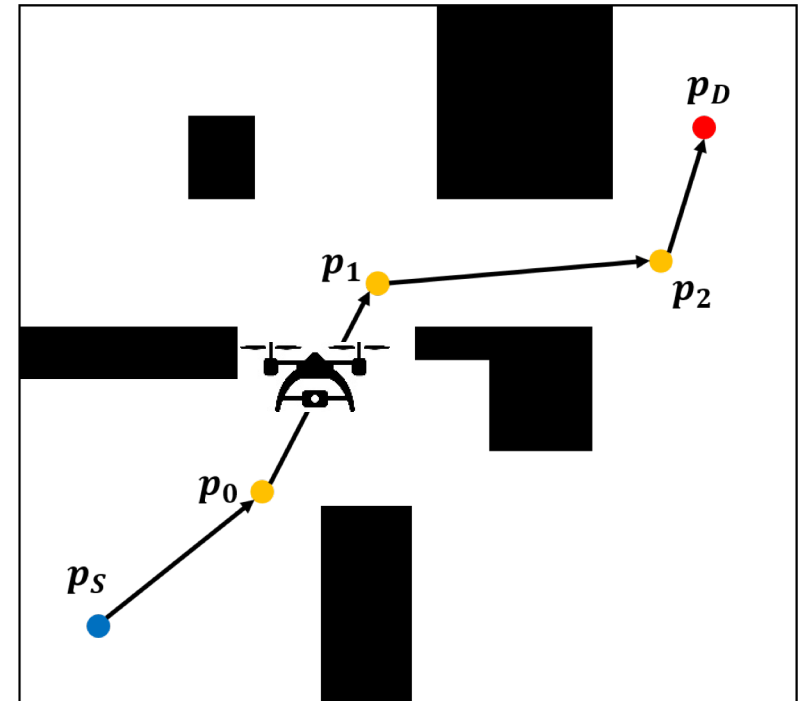


# Overview of Drone Path Planning



# Drone Path Planning Problem

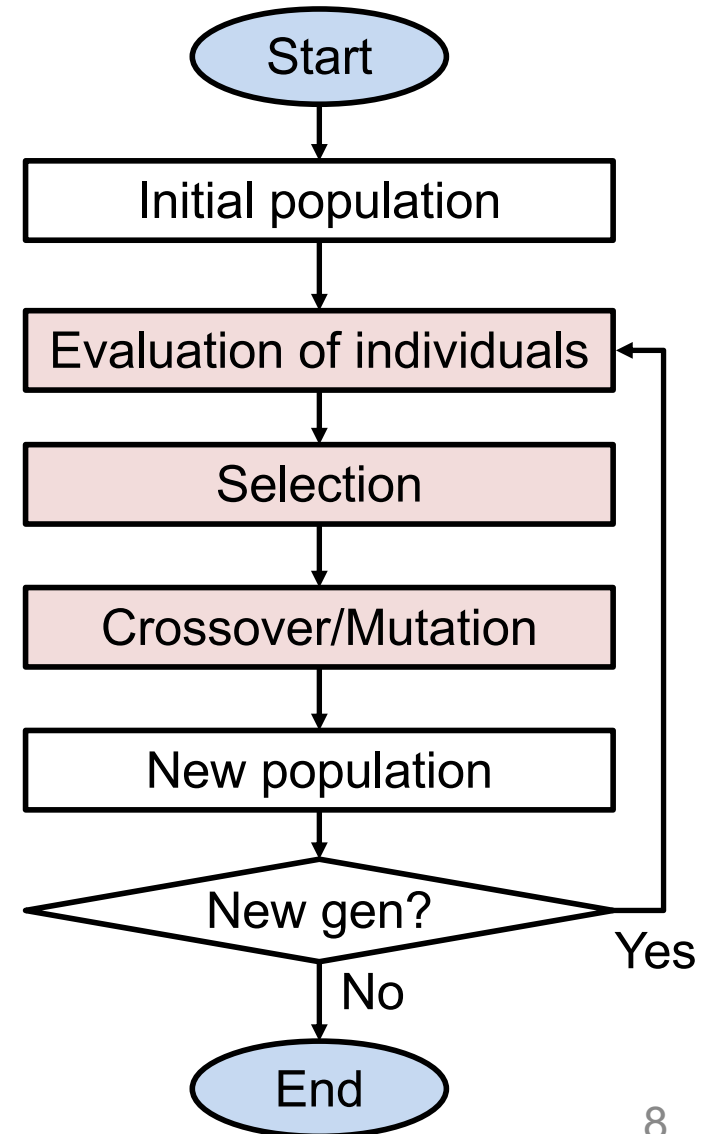
- Input
  - Origin and Destination
  - Obstacles
- Output
  - Waypoints
- Constraint
  - Safety distance
  - Turning angle
  - Risk (distance from the obstacles), etc.
- Minimize
  - Flight time, total risk, etc.



**Path planning problem is often solved by meta heuristics such as GA**

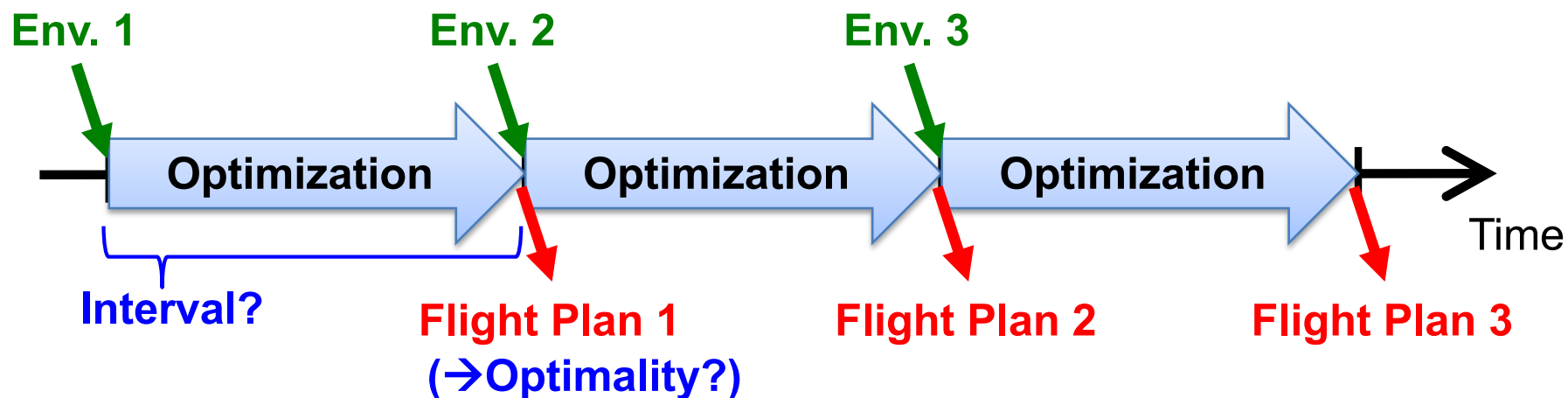
# EA based Path Planning Algorithm\*

- Each way point is represented as chromosome
  - Solution = set of WP
- Solutions are evolved for every generations
  - Updating the coordinate of WP
  - Crossing-over with the other solutions
- Tuning knobs
  - Population, generation
  - Crossing-over, mutation algorithm





# Online Optimization of Path Planning



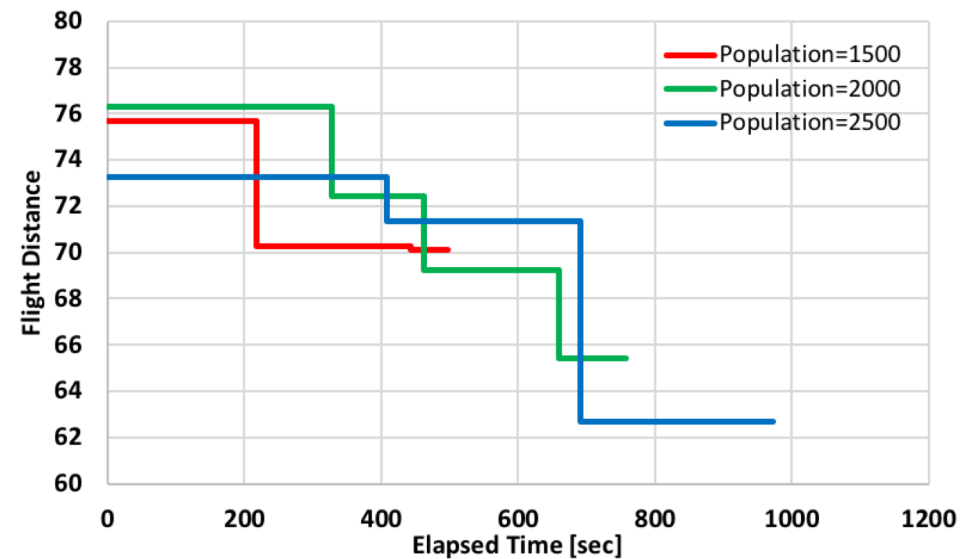
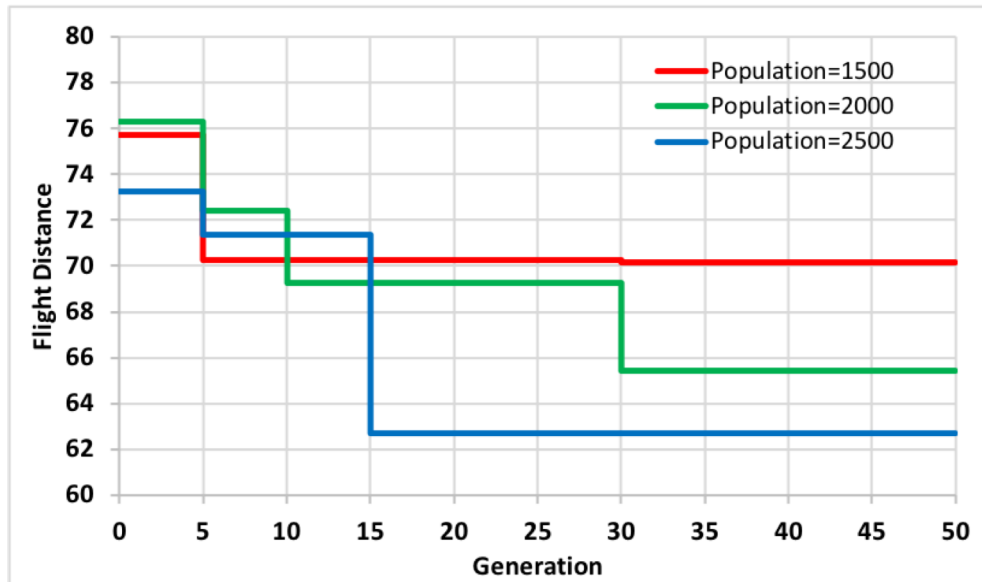
- Path planning problem is solved iteratively on-board
- Suitable “interval” and “optimality” are decided by application design
  - Interval = time constraint to solve the problem
  - Optimality = capability of algorithm (quality of solution)

**Exploration both of algorithm and hardware is necessary to satisfy “interval” and “optimality”**

# Algorithm Exploration

## – Flight time vs Optimization intervals

Method: P. Yang, IEEE Trans. on Robotics, 2015



- Solving time is depends on the algorithm parameters
  - Population, generation, mutation, crossover, etc.
- Effective parameter set is different under the given solving time constraint (=interval)
- Hardware implementation is necessary with tuned algorithm

# Summary and Future Work

- Summary
  - Online optimization for drone path planning problem
    - Path planning problem is solved iteratively during flight on-board embedded system
  - Exploration both of algorithm and hardware
- Future work
  - HW/SW Co-design for online optimization application
  - X-layer co-design of application, algorithm, and hardware
    - Whole system design considering QoS through various cost