Precision Control in Industrial Mobile Manipulators: Challenges and Solutions.

2nd Public Technical Course
Moira – 05/06/2024

Naroa Núñez-Calvo

1. Introduction
2. Problem Statement
3. Actual Solutions
4. Current Challenges
5. Proposed Control
6. Conclusions

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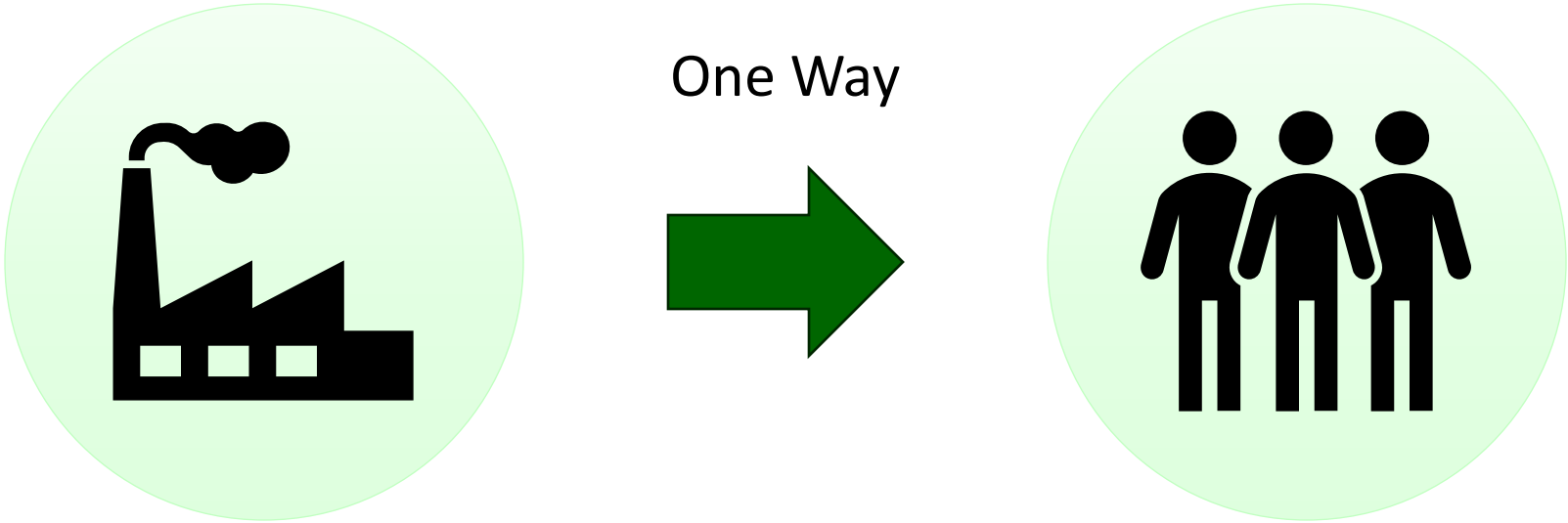
Industry.

Before

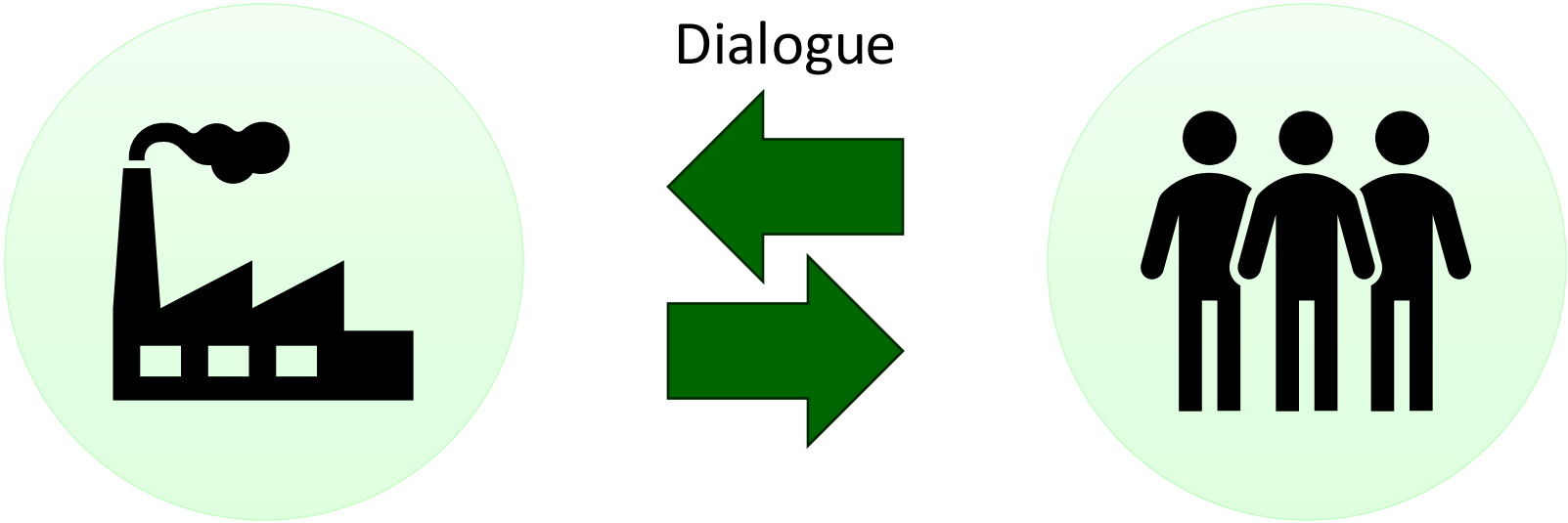


Mass production

Industry.

After

Interactive Dialogue

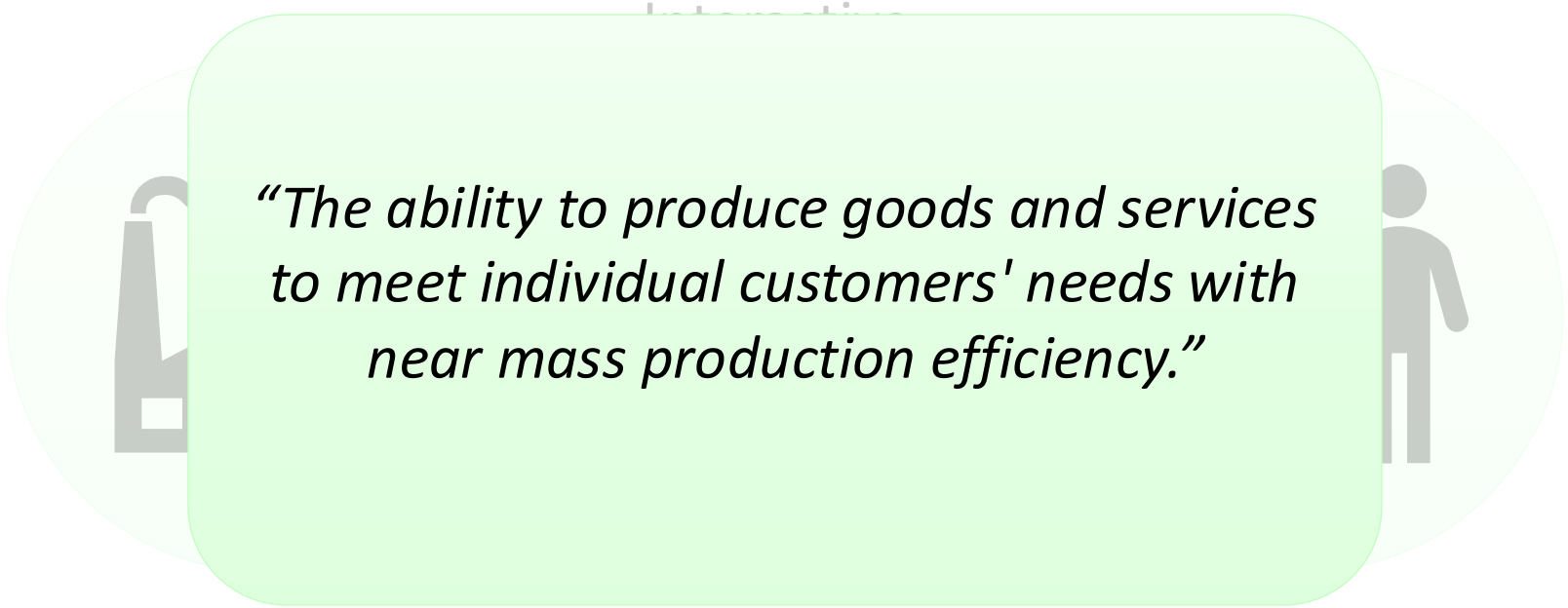


Mass customization

Industry.

After

Mass customization



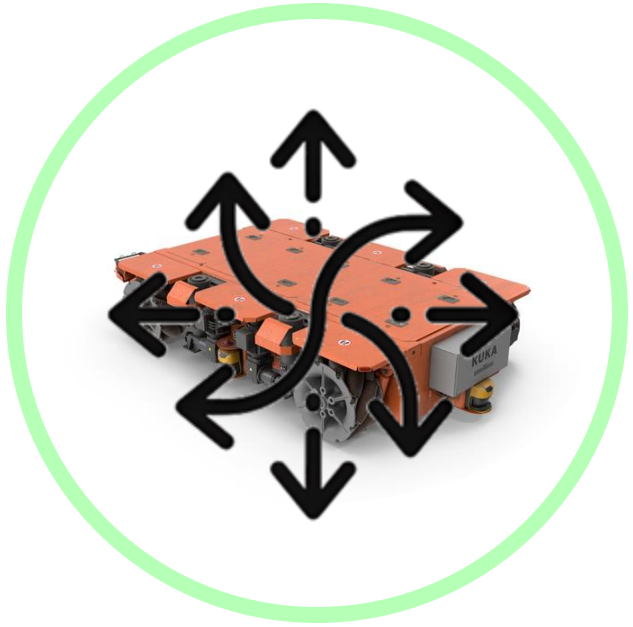
“The ability to produce goods and services to meet individual customers' needs with near mass production efficiency.”

Industry.

Mass customization

Task Execution

Robot Manipulator



Flexibility

Mobile Platform

Industry.

Robot Manipulator

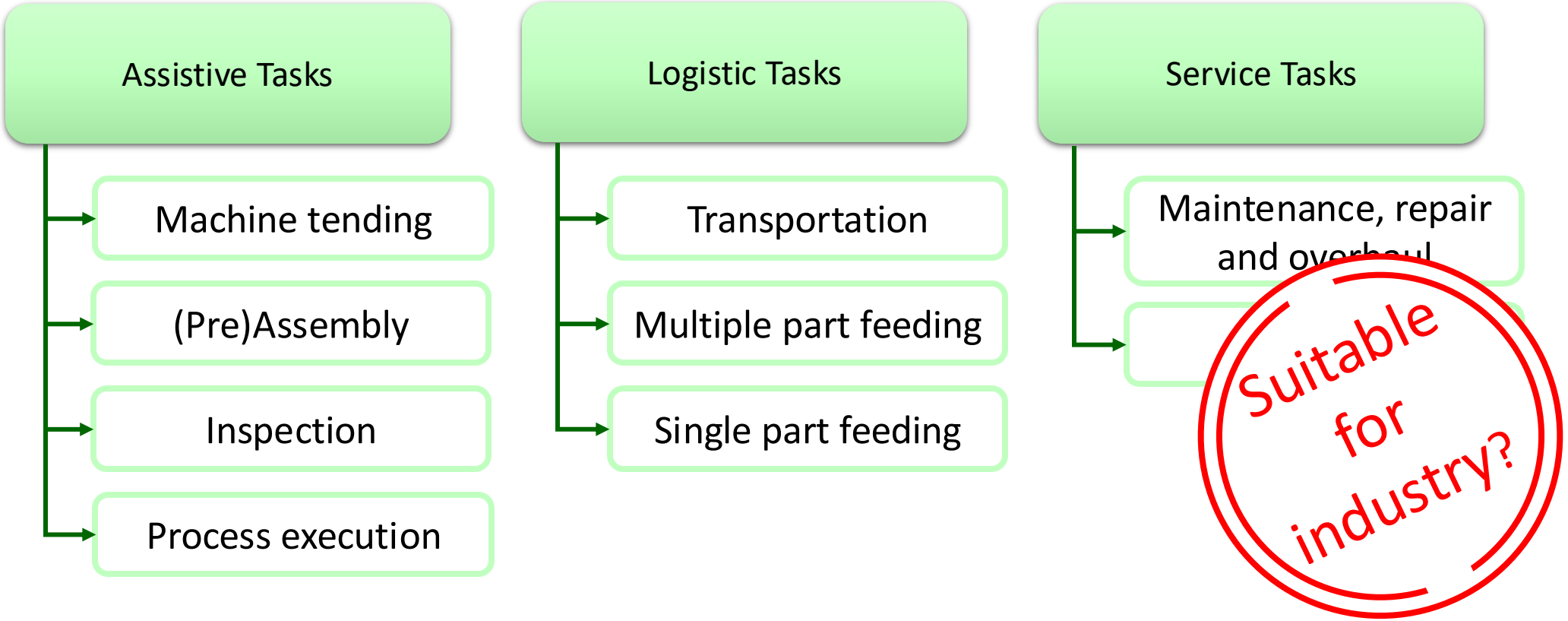
+

Mobile Platform

=

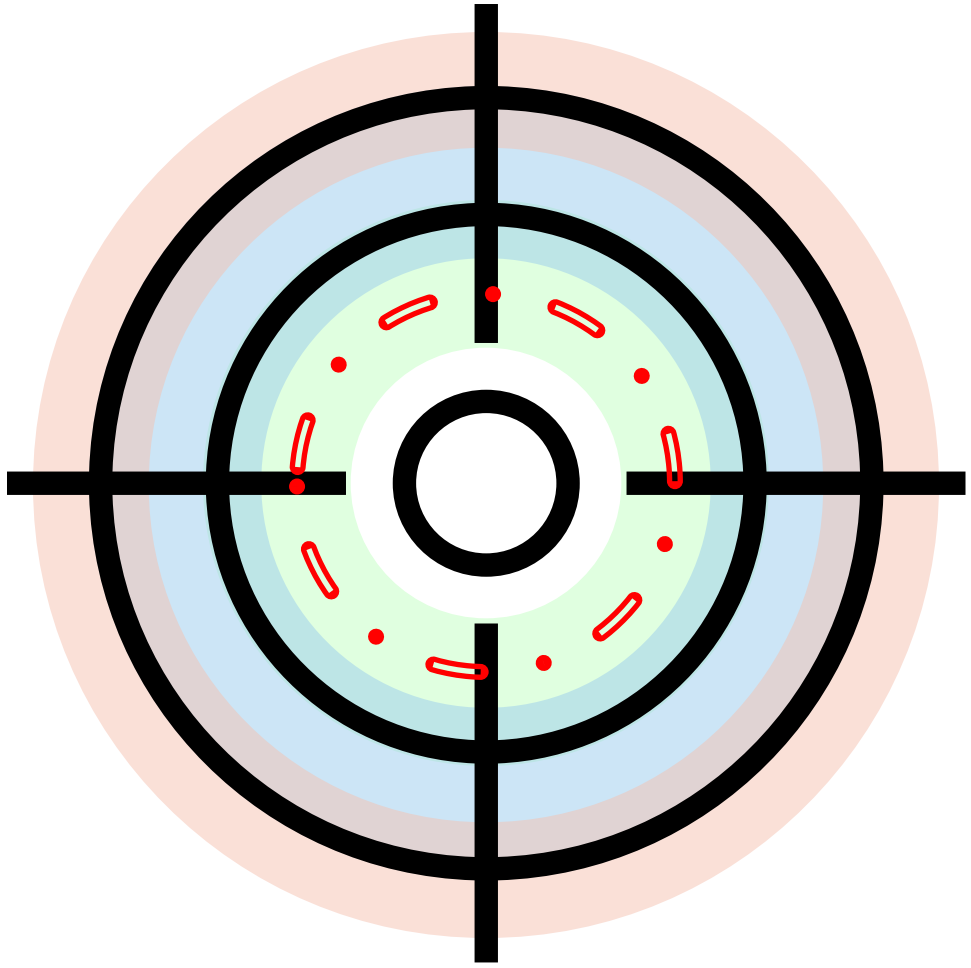
Mobile Manipulator

Mobile manipulator.



Problem.

Tool's precision



Industry requirements

- Reduced takt time
- Robustness
- Precision: ±1mm

Mobile Manipulator

Robot Manipulator

- Repeatability: ±0.1mm ~ ±0.3mm
- Precision: ±1mm ~ ±3mm

Mobile Platform

- Precision: ±30mm

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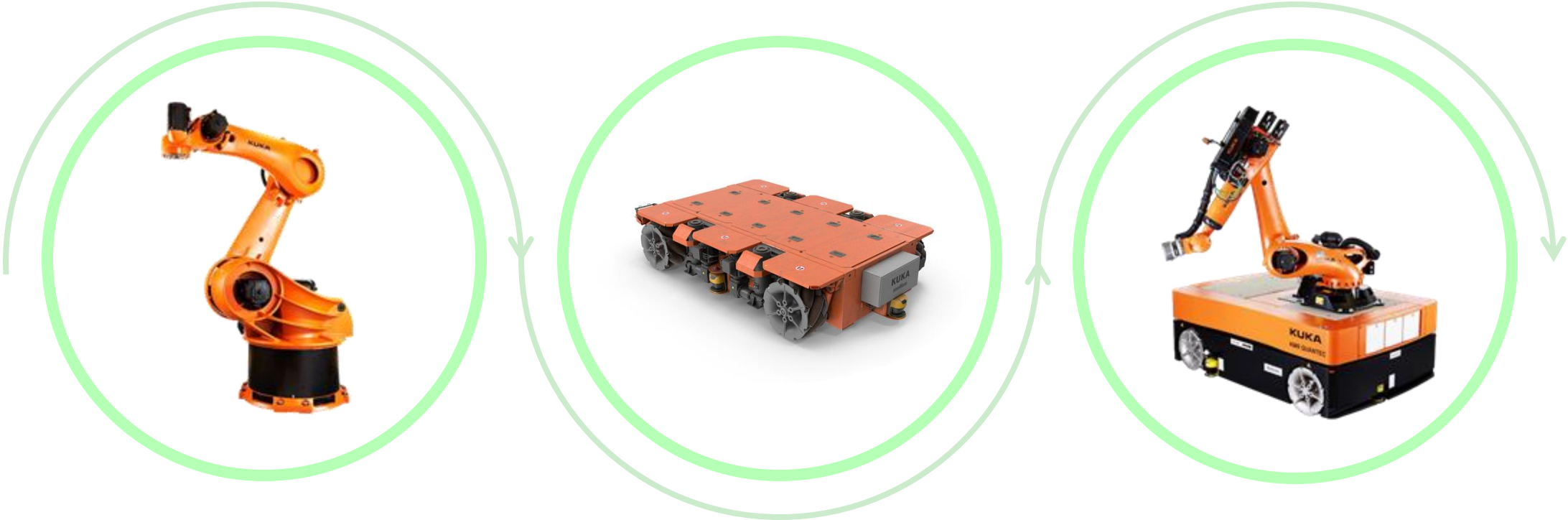
Source of errors.



Robot Manipulator

Mobile Platform

Mobile Manipulator

Robotic Manipulator.

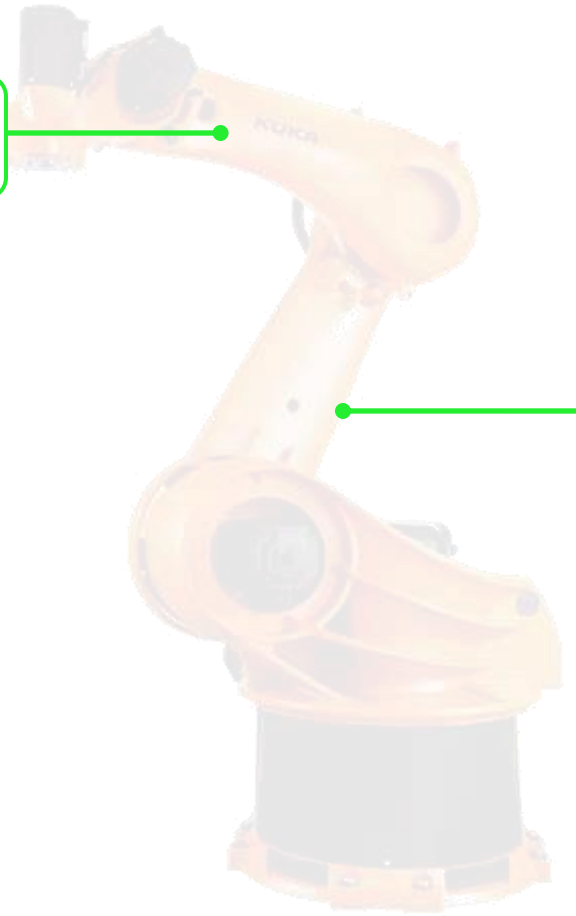
Deviation between the nominal parameters and actual parameters

Deformations generated by forces or torques associated with the tool or workpiece

Robotic Manipulator.

Geometric errors

- Length of the links
- Joint offsets
- Assembling errors



Deformations generated by forces or torques associated with the tool or workpiece

Robotic Manipulator.

Geometric errors

- Leng… …inks
- …
- Ass… …rs

BIGGEST ERRORS

Non-geometric errors

- Compliance errors
- Friction, backlash, gear transmission
- Control errors
- Environment factors

Robotic Manipulator.

Geometric errors

- Length of the links
- Joint offsets
- Assembling errors

Non-geometric errors

- Co[illegible]s
- F[illegible]gear tra[illegible]
- Control errors
- Environment factors

BIGGEST ERRORS

Mobile Platform.

Mobile Platform.

Unknown wheel-ground contact

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Mobile Platform.

Unknown wheel-ground contact

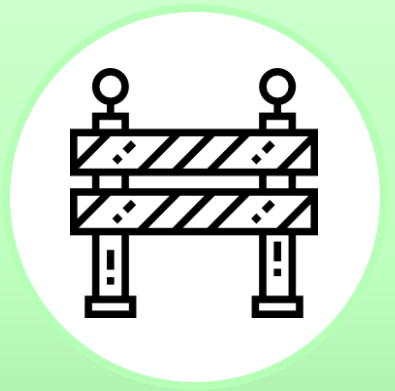
Slippage

Sensor-system

Mobile Platform.

Unknown wheel-ground contact

Slippage

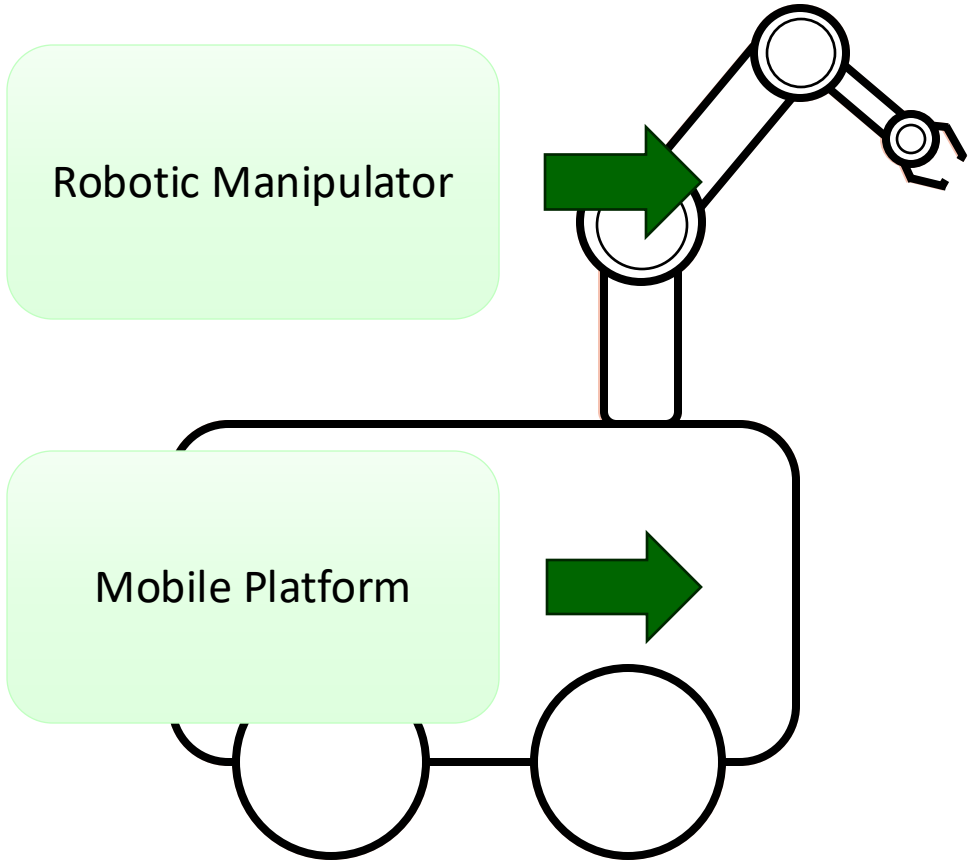


Dynamic environment

Error Measurement

Sensor-system

Mobile Manipulator.



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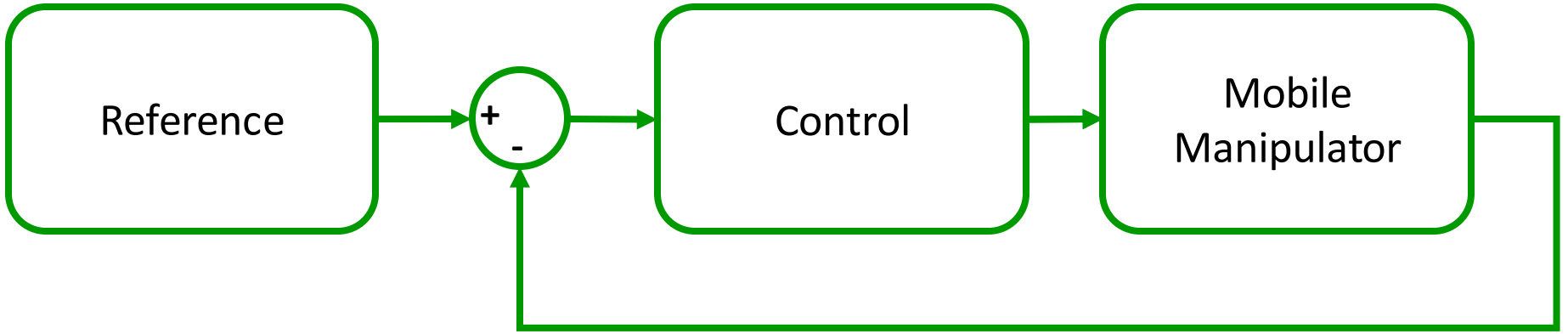
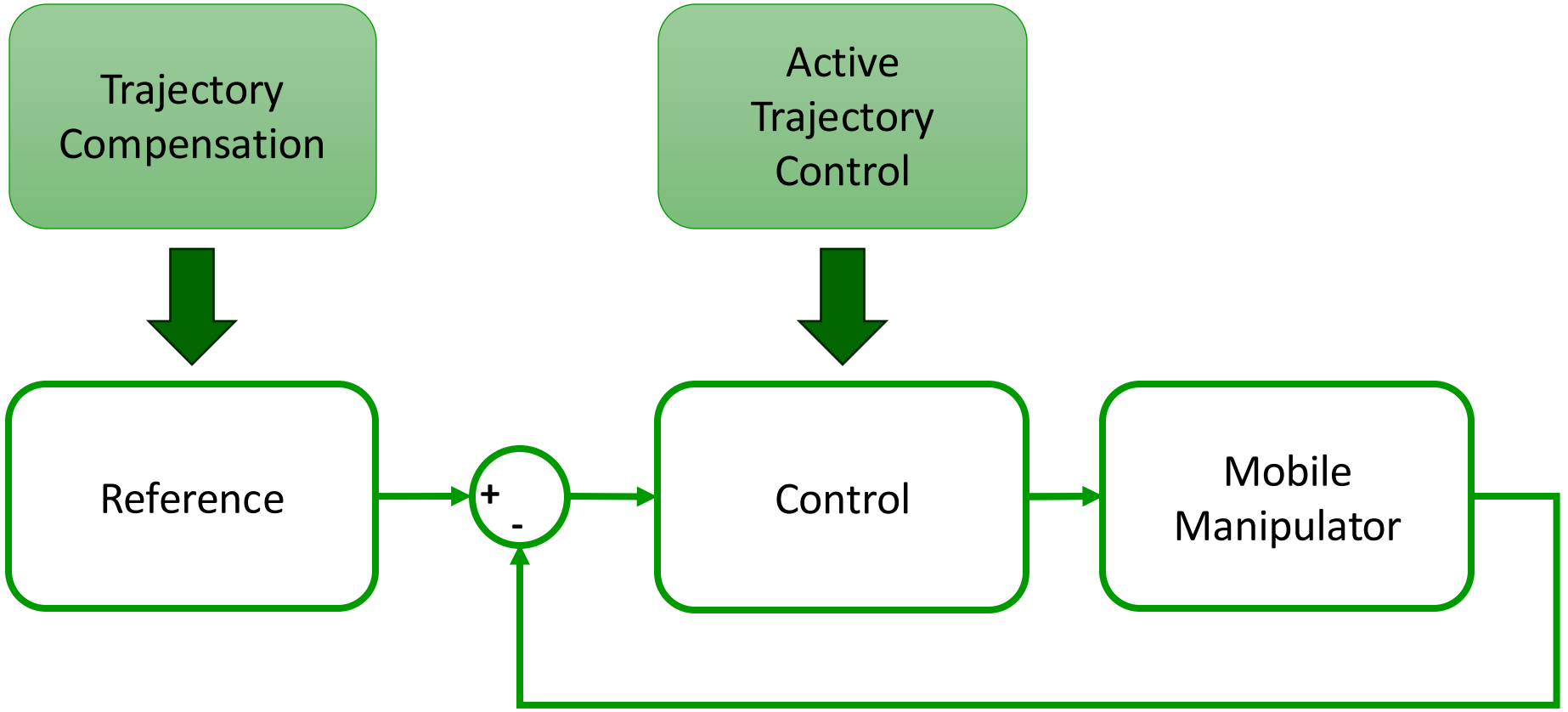
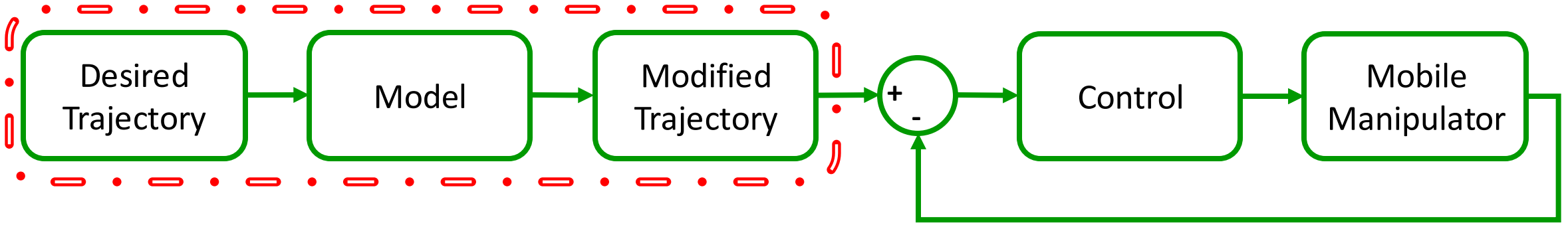
Main Scheme.



Main Scheme.



Trajectory Compensation.



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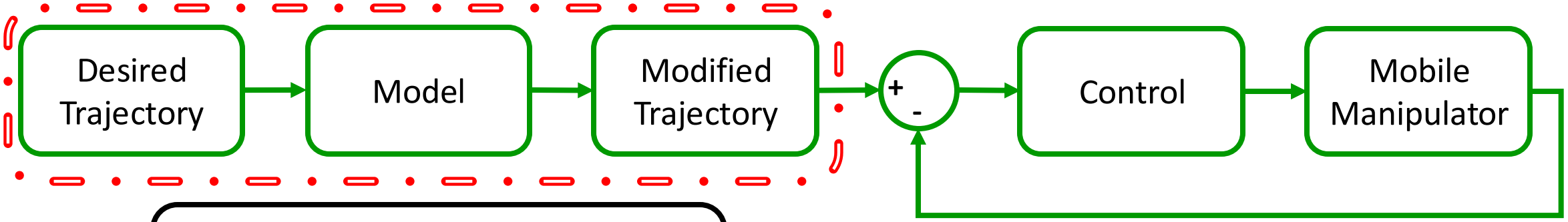
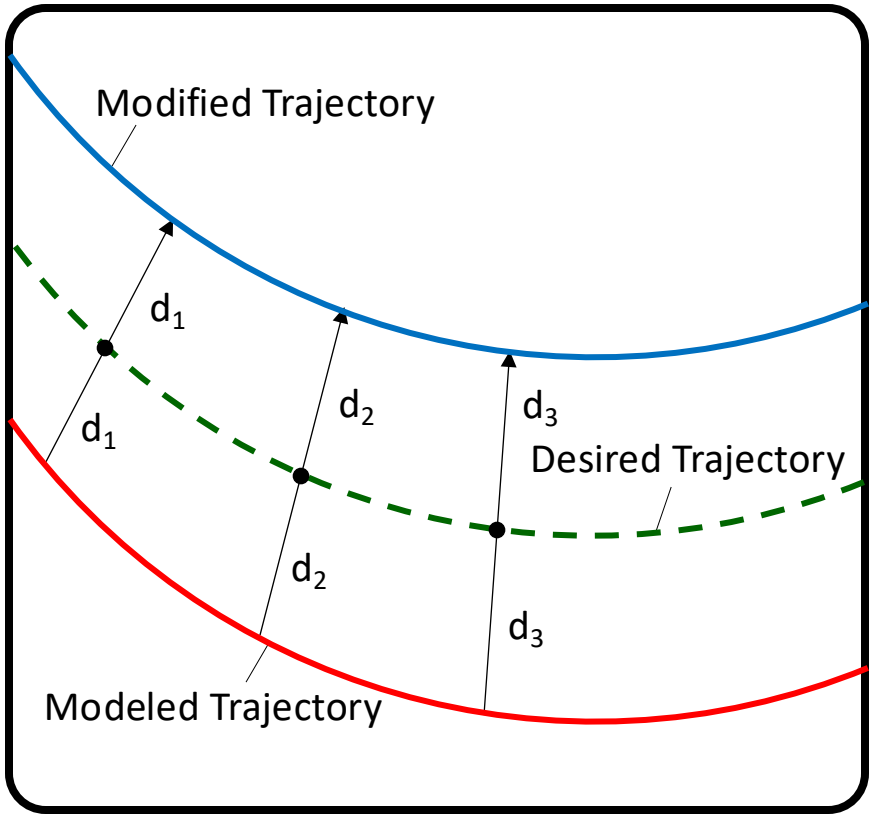
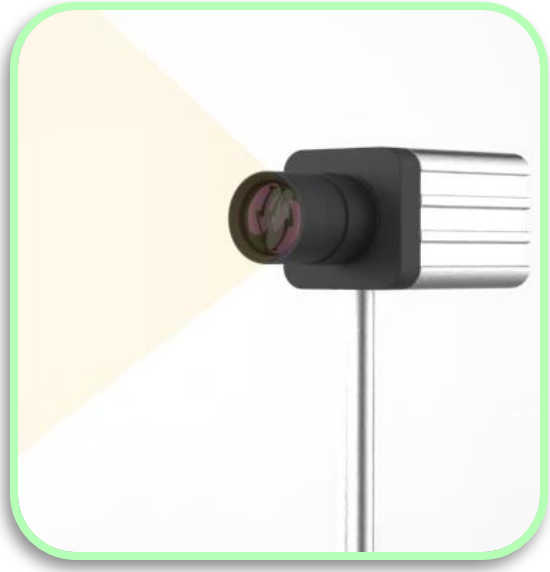


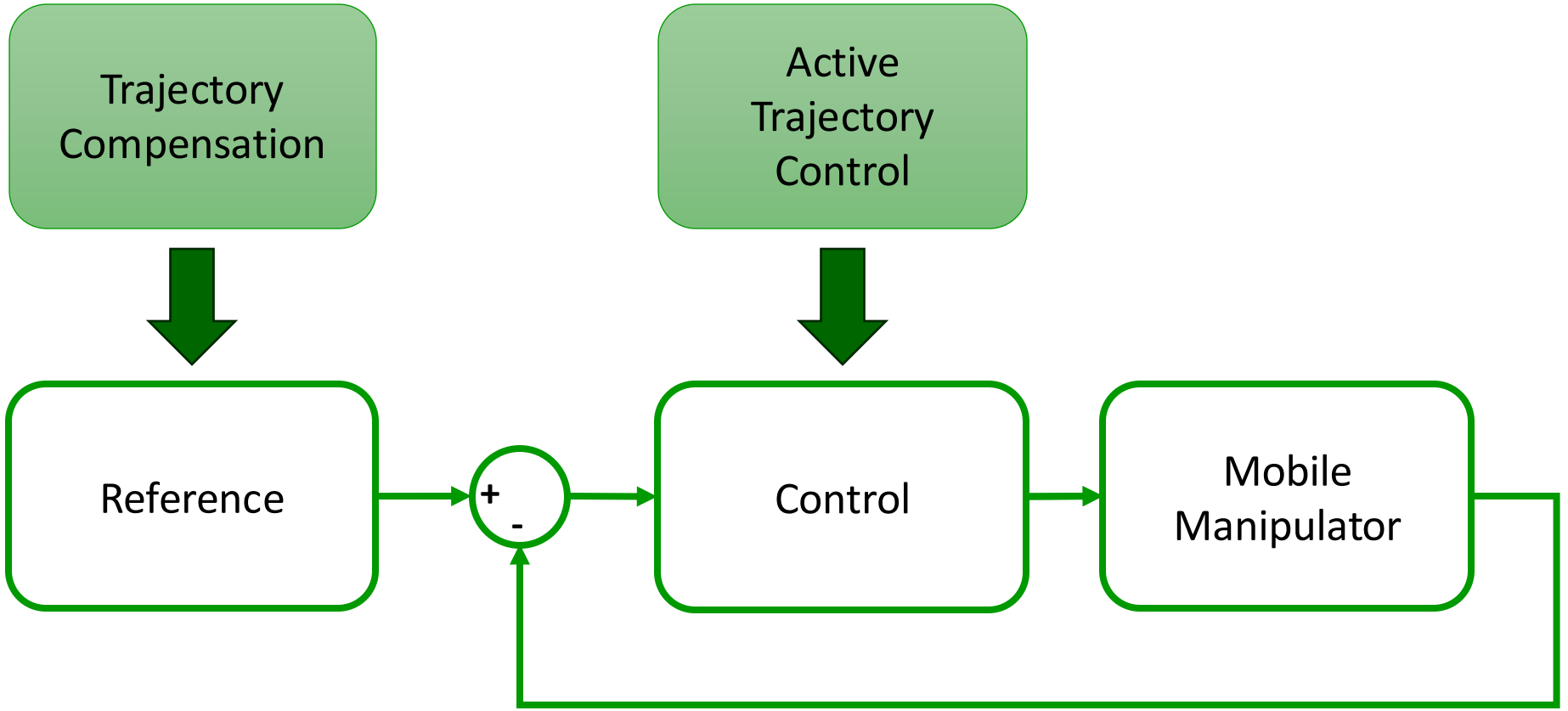


Laser Tracker



Camera

Main Scheme.



Active Trajectory Control.

Robot Manipulator

Mobile Platform

Mobile Manipulator

Active Trajectory Control.

Robot Manipulator

Synch Module

Mobile Platform

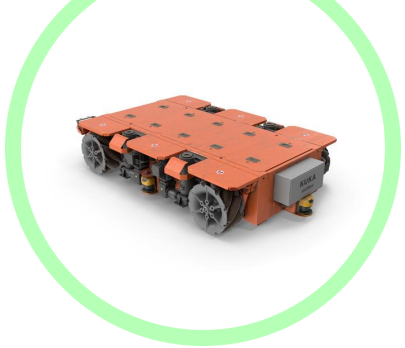
Decentralized Control

Mobile Manipulator

Active Trajectory Control.

Robot Manipulator

Synch Module



Mobile Platform

Decentralized Control

Mobile Manipulator

Centralized Control

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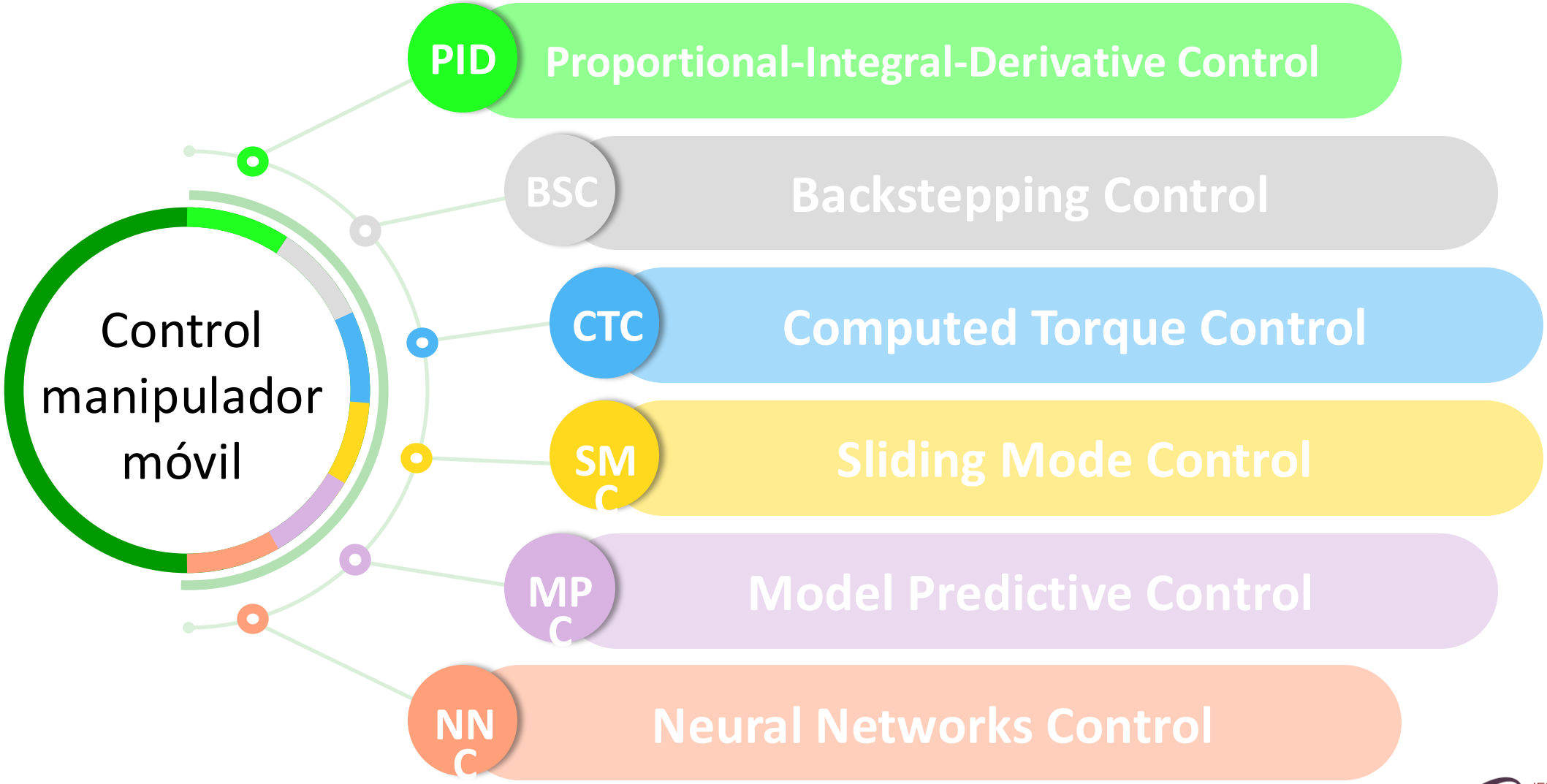
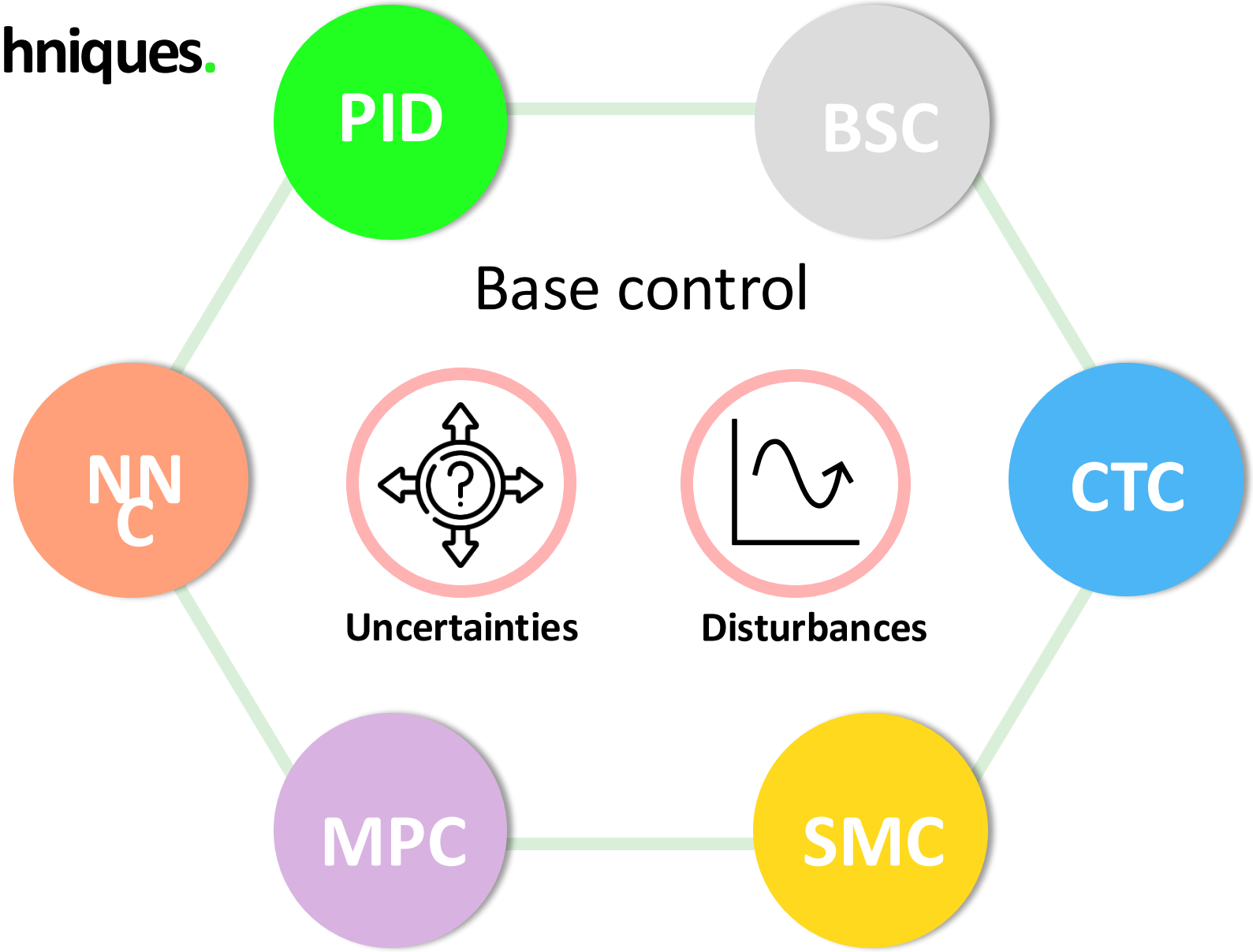
Control Techniques.



Control Techniques.



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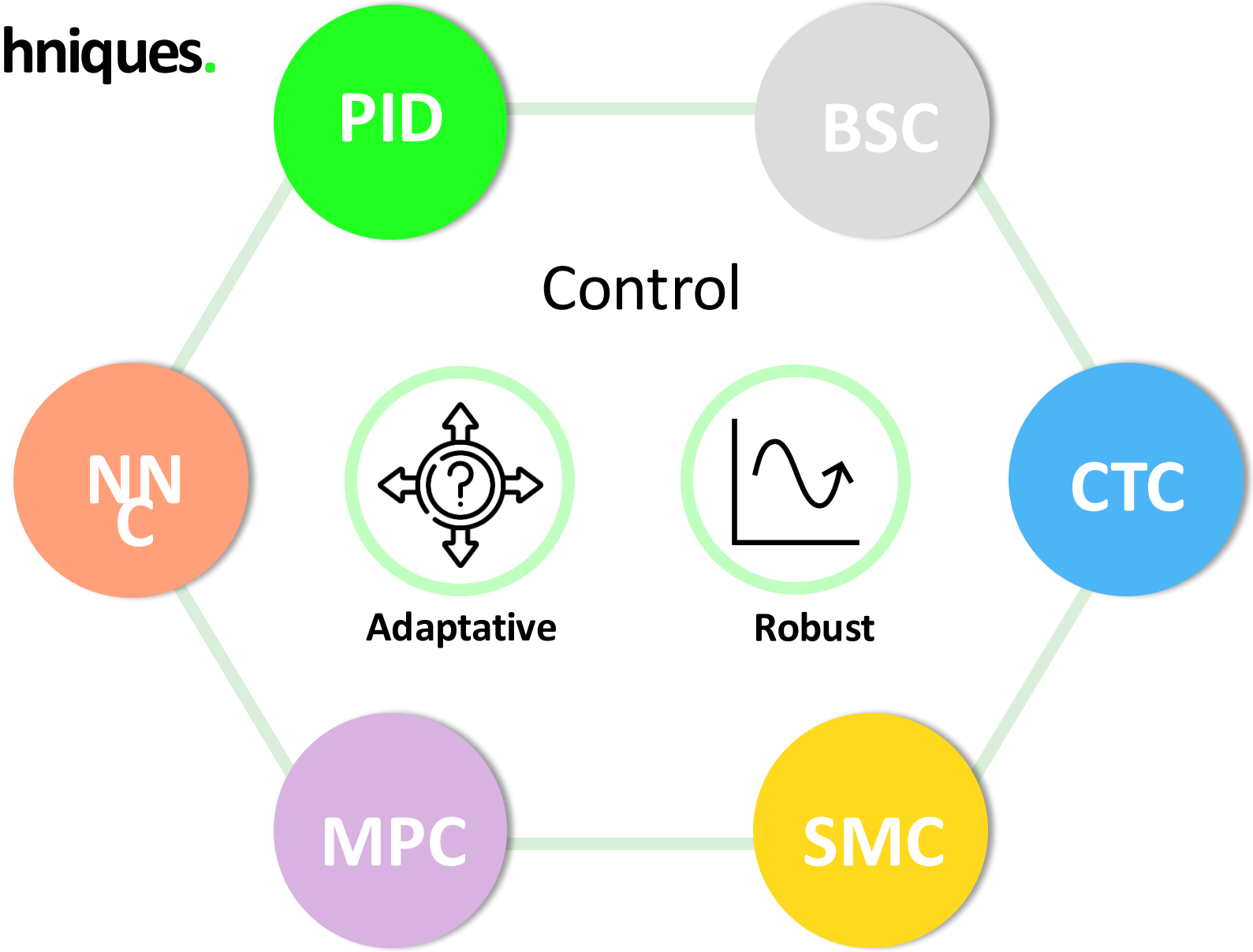

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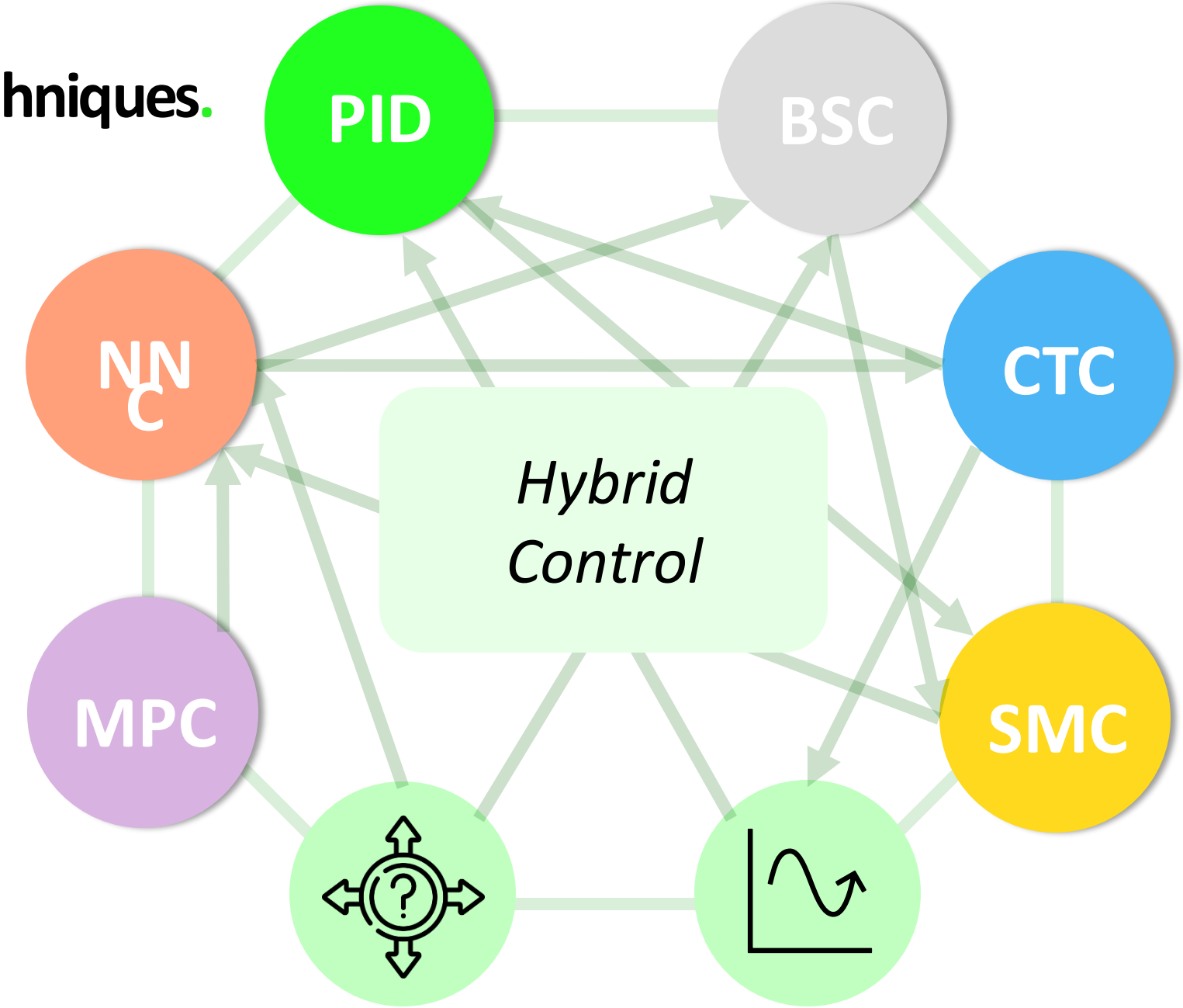

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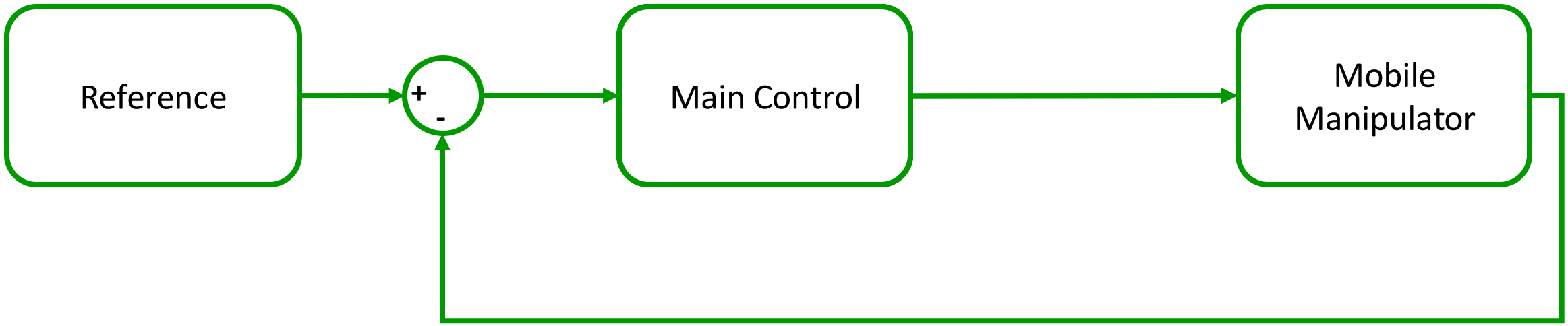

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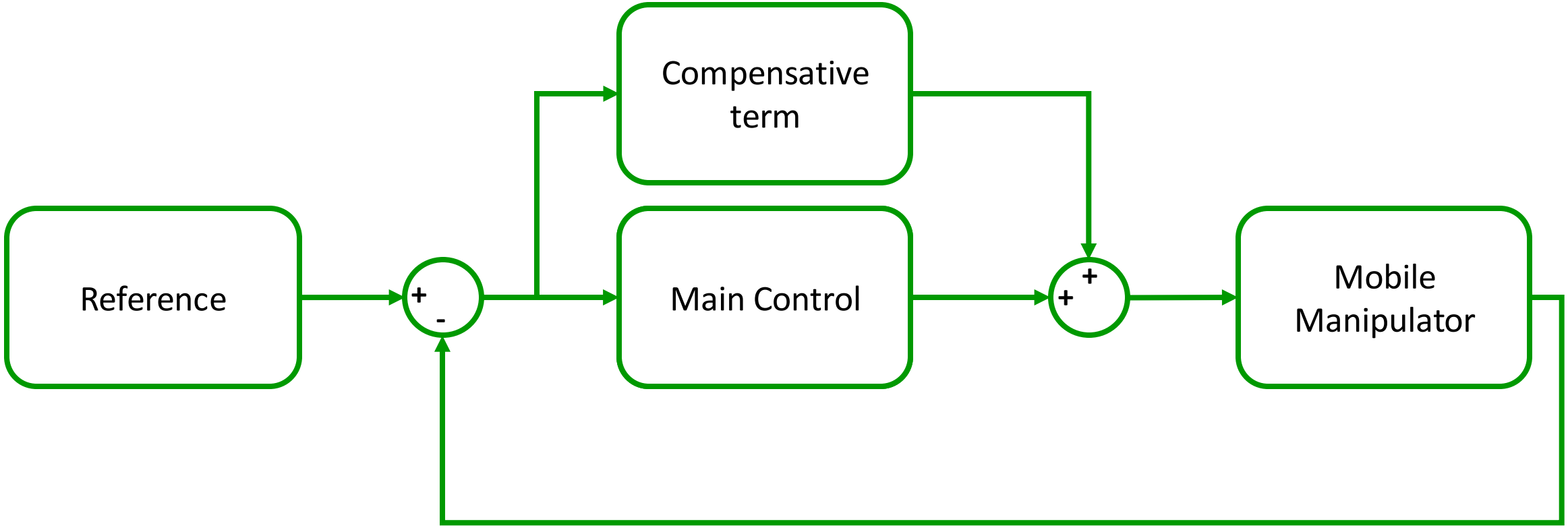

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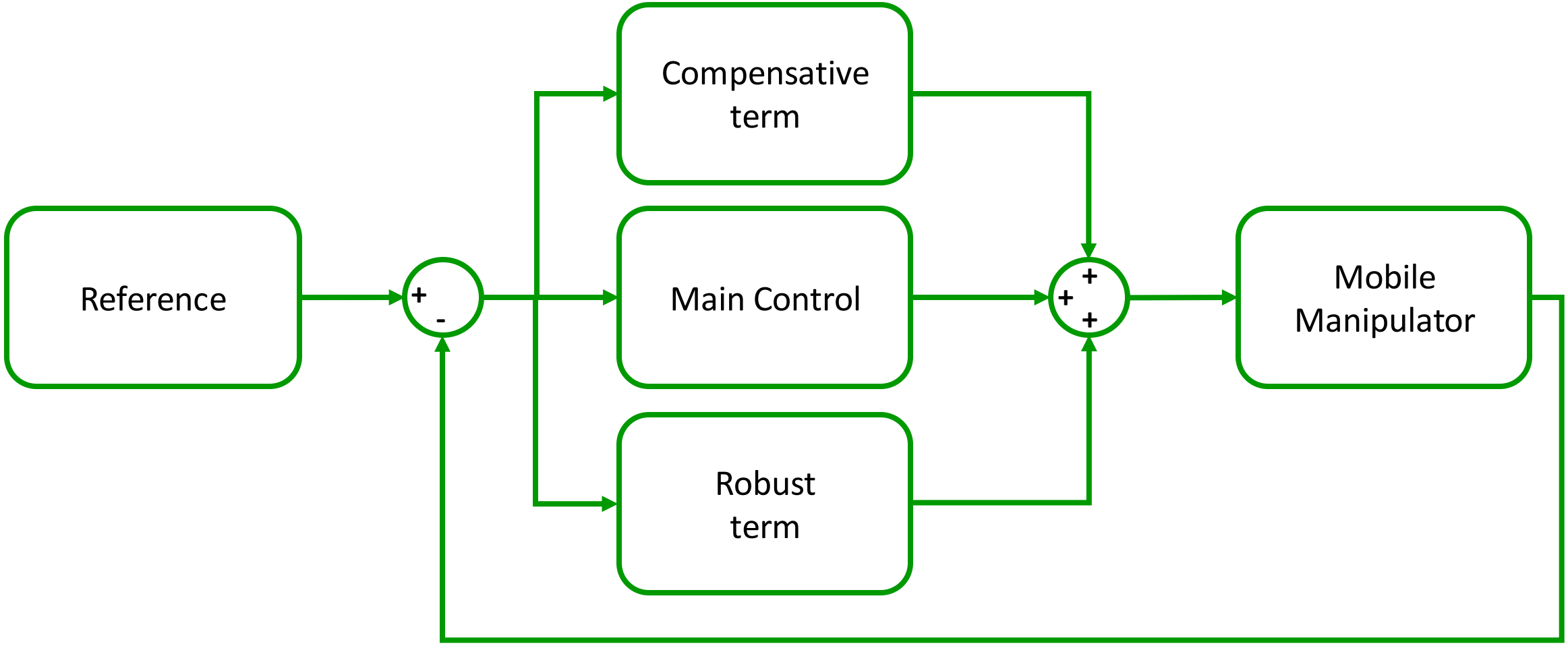

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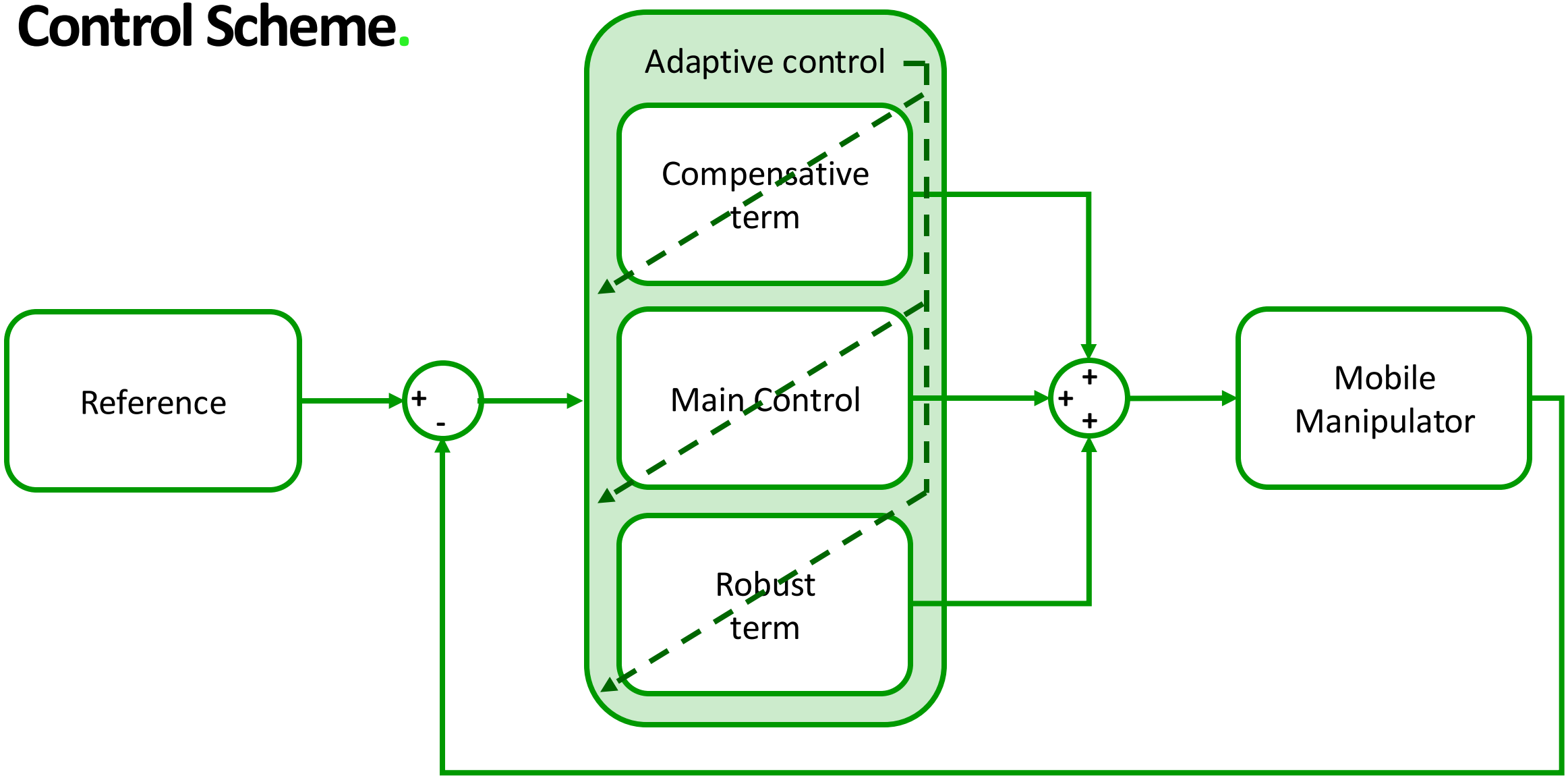

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Current Challenges.

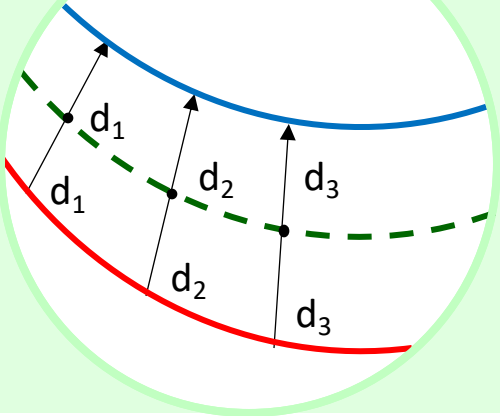
Precision Errors

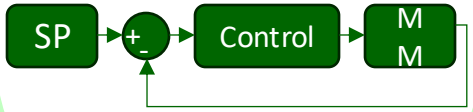
Actual Solutions

Current Challenges.

Precision Errors

Actual Solutions





Current Challenges.

Precision Improvement

Control Complexity

Union of solutions

Current Challenges.

Precision Improvement

Control Complexity

Coupled Dynamic

Simulation experimentation

Less Degrees of Freedom

Union of solutions

Current Challenges.

Precision Improvement

- Error compensation
- Improved functionality
- Low Cost

Control Complexity

- Coupled Dynamic
- Simulation experimentation
- Less Degrees of Freedom

Union of solutions

Current Challenges.

Precision Improvement	Control Complexity	Union of solutions
Error compensation	Coupled Dynamic	Overcoming challenges
Improved functionality	Simulation experimentation	Reduced Complexity
Low Cost	Less Degrees of Freedom	Easy to program/modify

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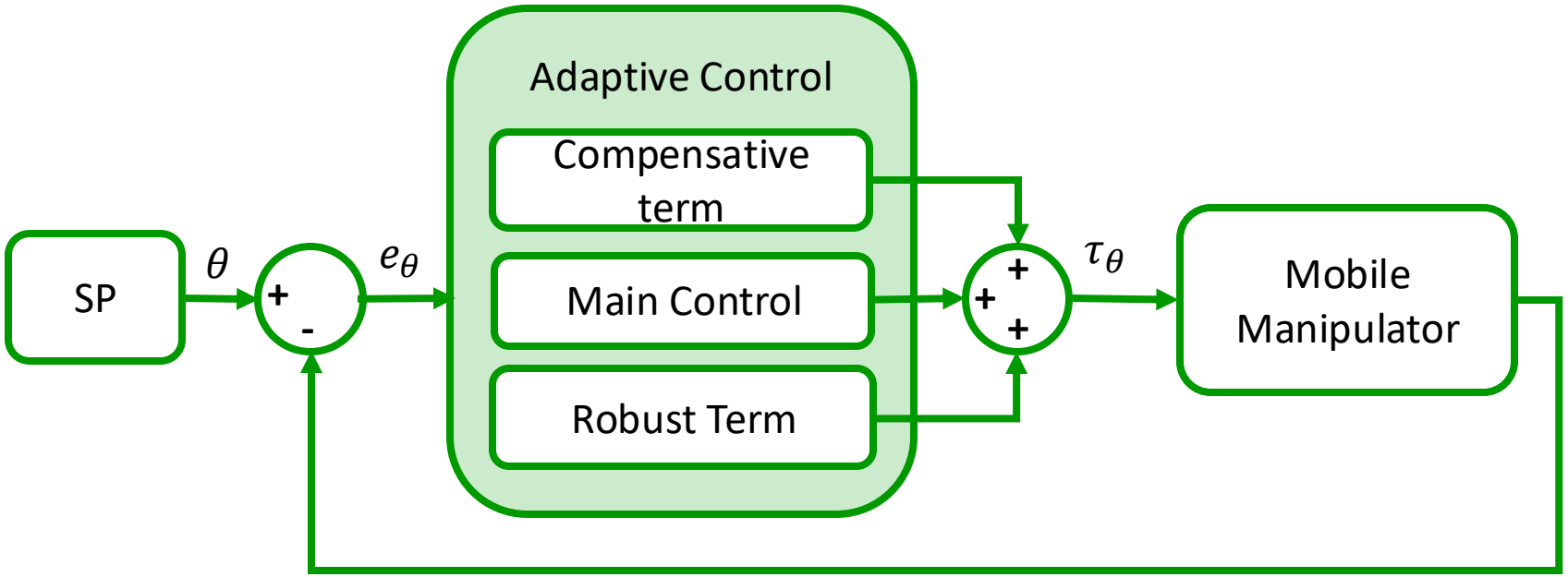

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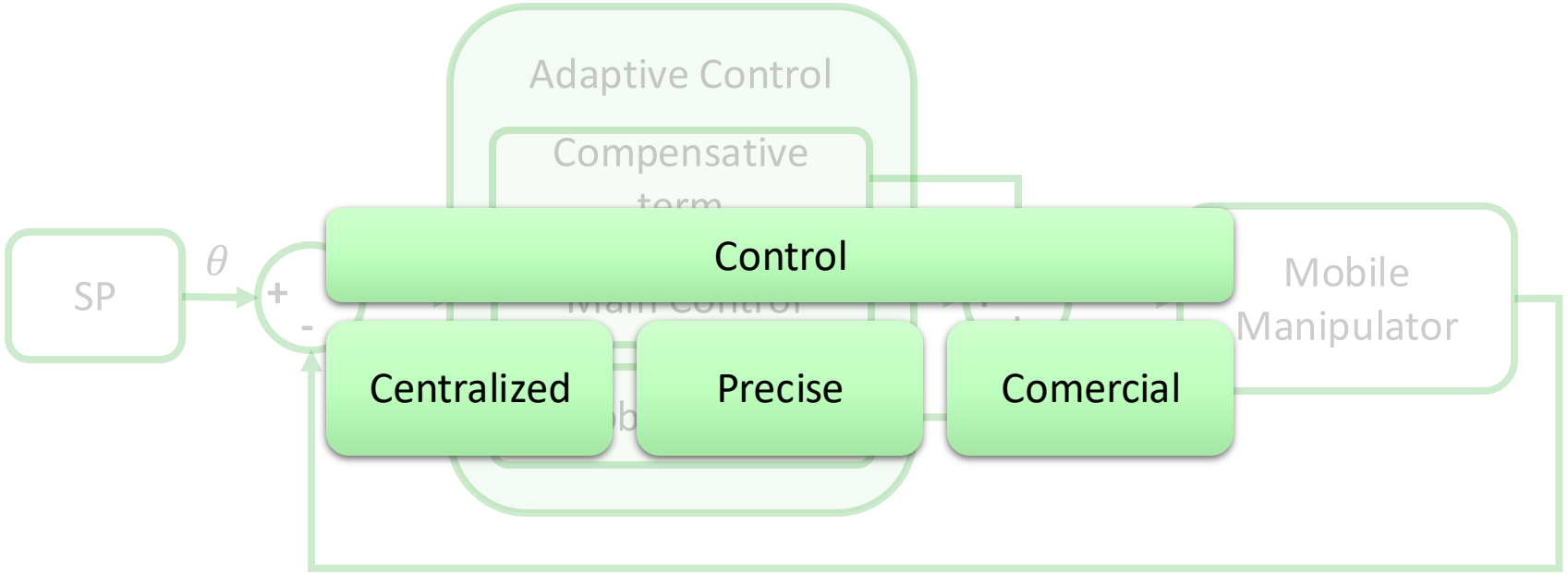

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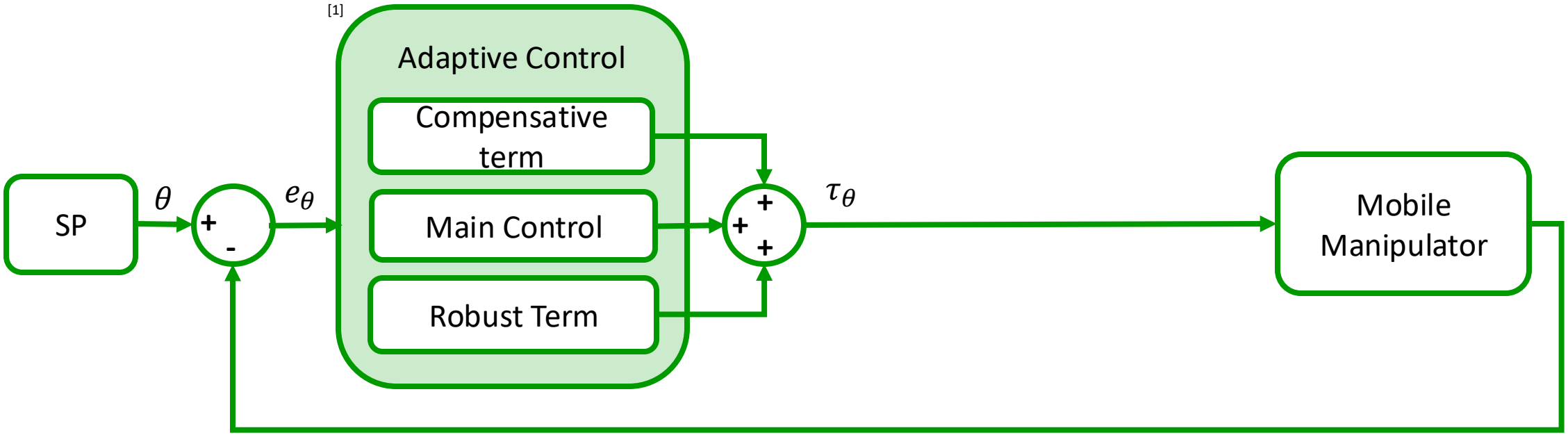


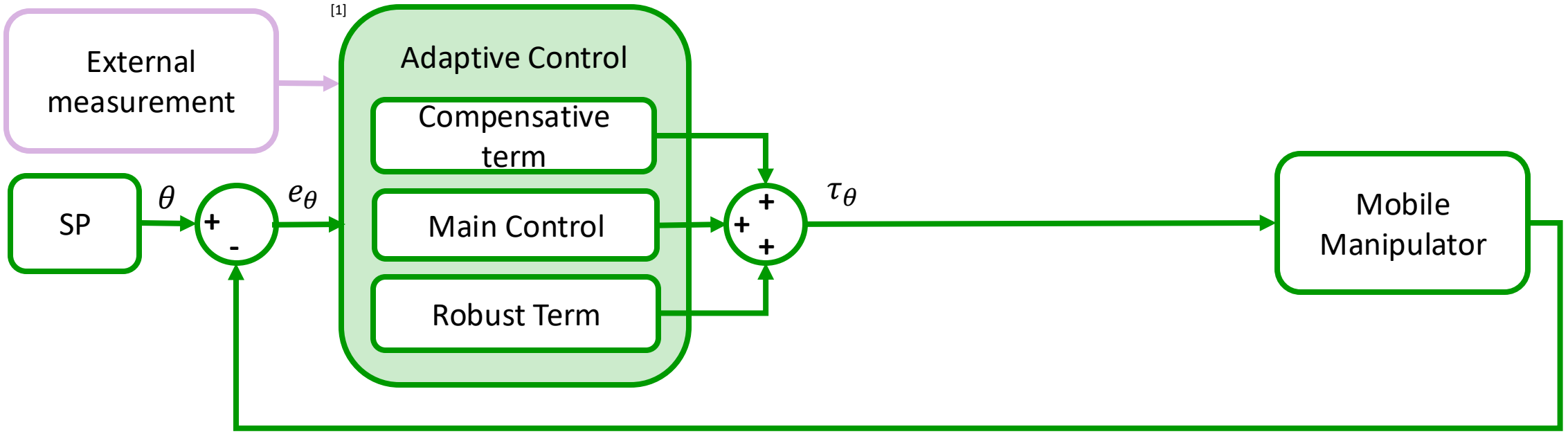
Centralized

Precise

Comercial

[1] Thang Long Mai and Huu Toan Tran. An adaptive robust backstepping improved control scheme for mobile manipulators robot. ISA Transactions, 137:446–456, 6 2023

Control Scheme.



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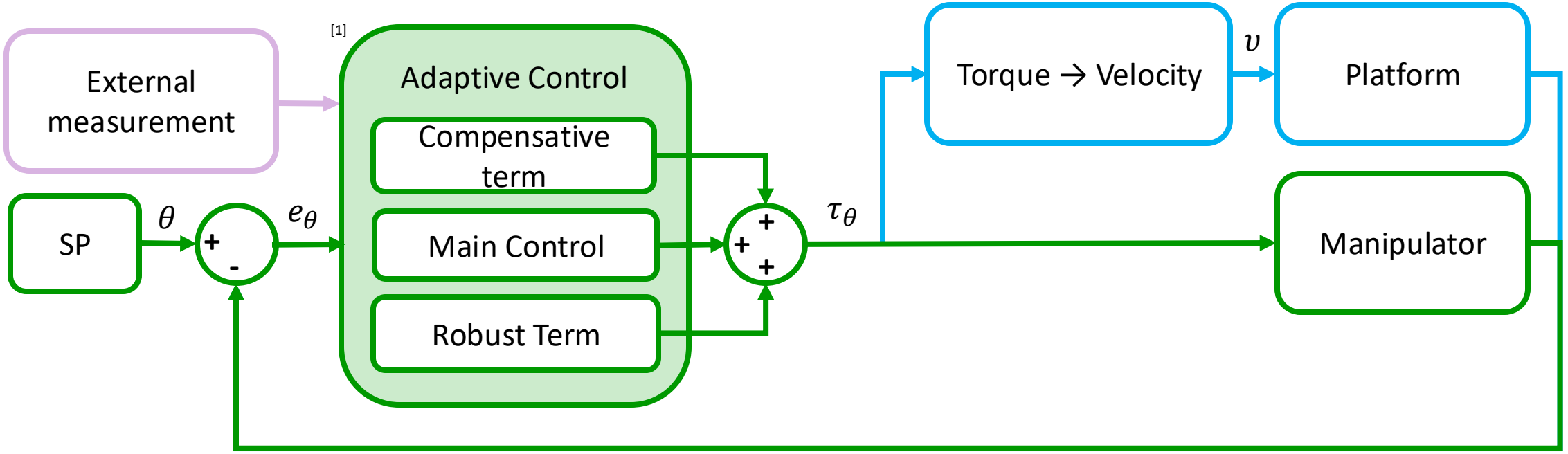

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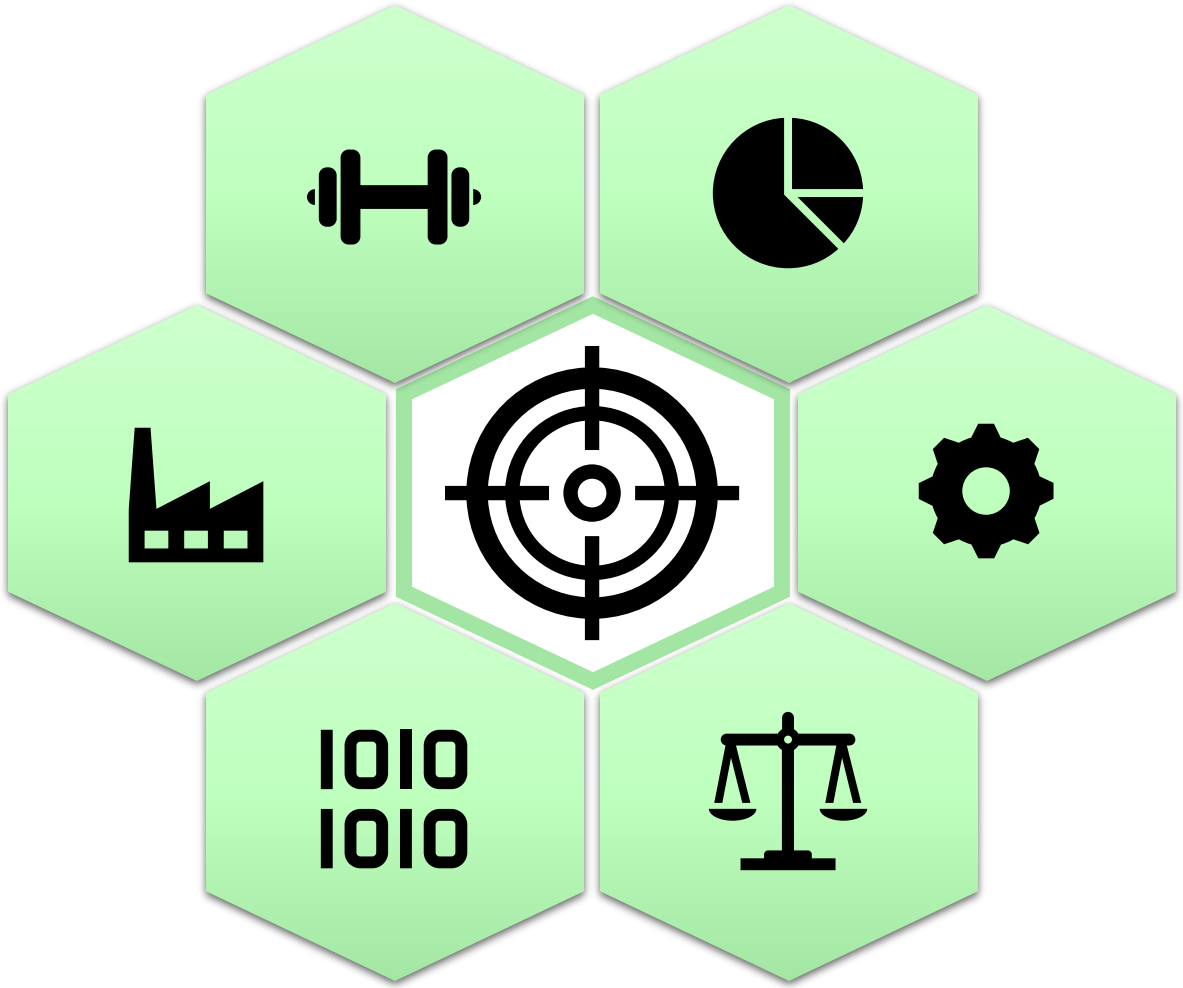
Final objective.



Final objective.

Dynamic Control

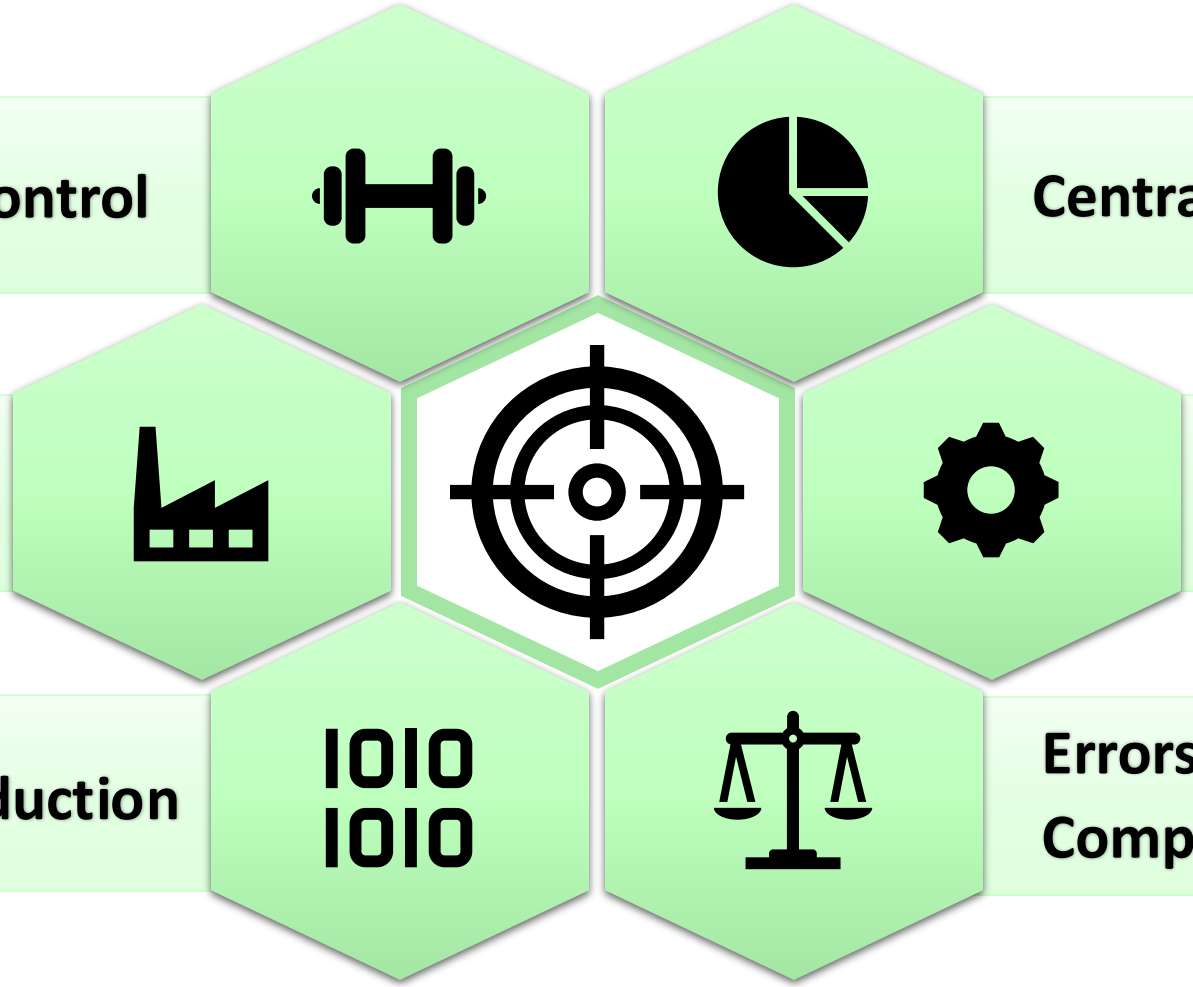
Centralized Control

Real Scenario

Degrees of Freedom

Computational Cost Reduction

Errors and Disturbances Compensation



Thank you very much!

For more information follow us on:

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