Securing the Control and Navigation Surfaces

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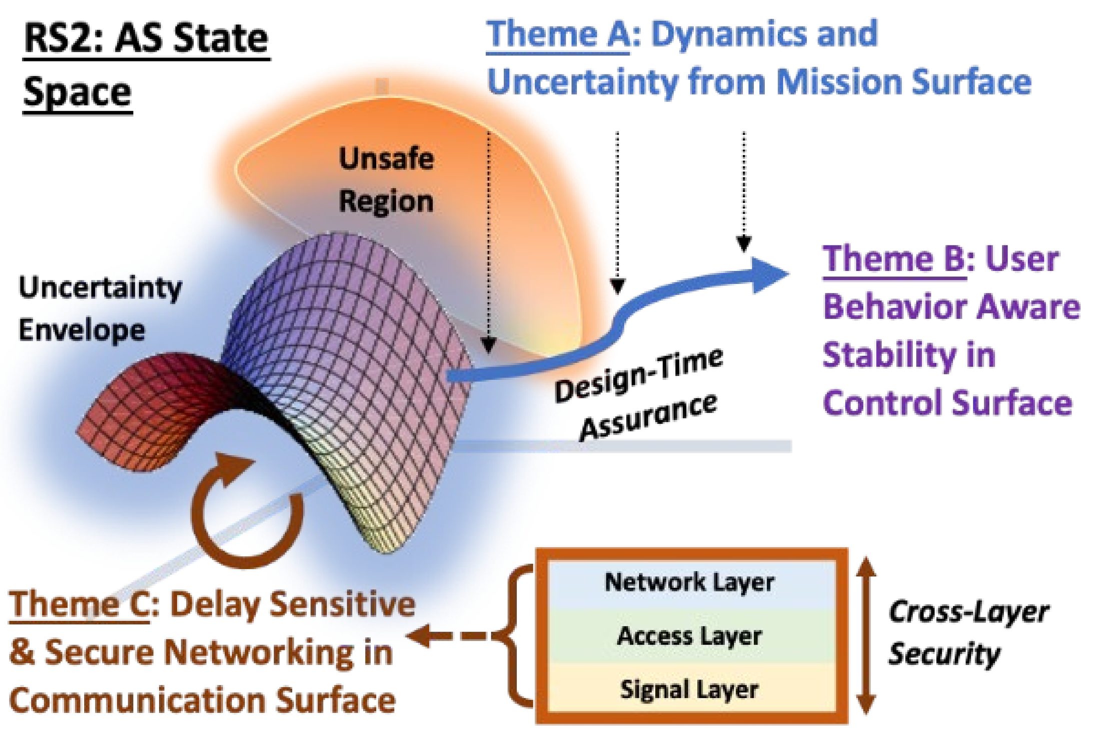
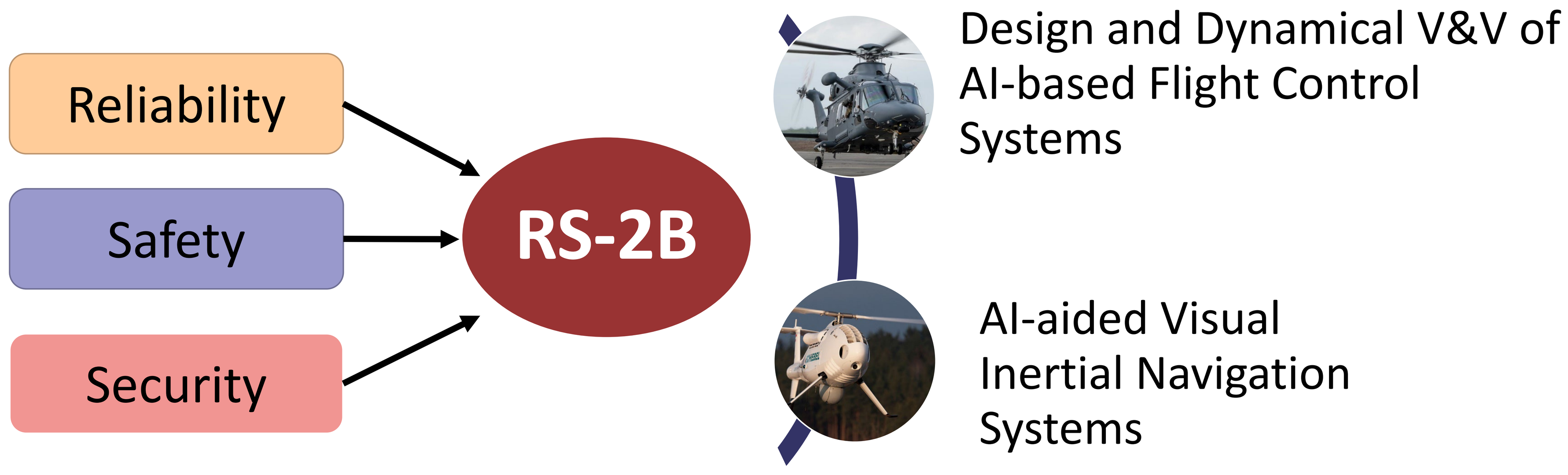
1. Role of the RS-2B



Ability of runtime adaptations of control and navigation systems over attacks or "perceived" attacks:

- Adversaries
- Environment uncertainties
- Degraded performance

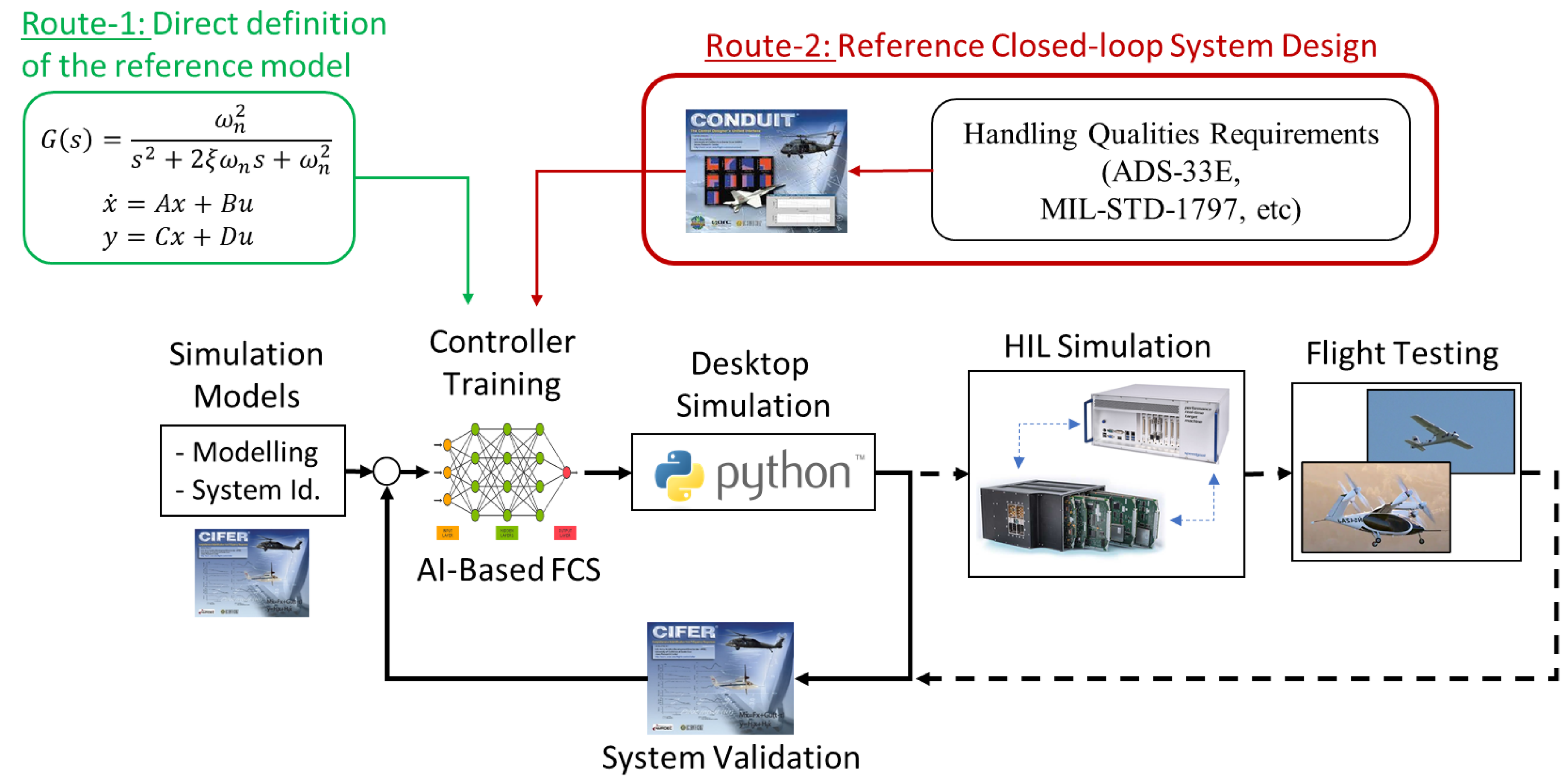


1. AI-Based Flight Control System Design

Aim of this Study:

- Designing an RL-based flight control system
  - Covering the whole flight envelope
  - Integrating handling qualities into the training process
  - Validation of the closed-loop dynamics

Design Methodology Overview



Validation of the Closed-loop System Dynamics in Simulation Environment

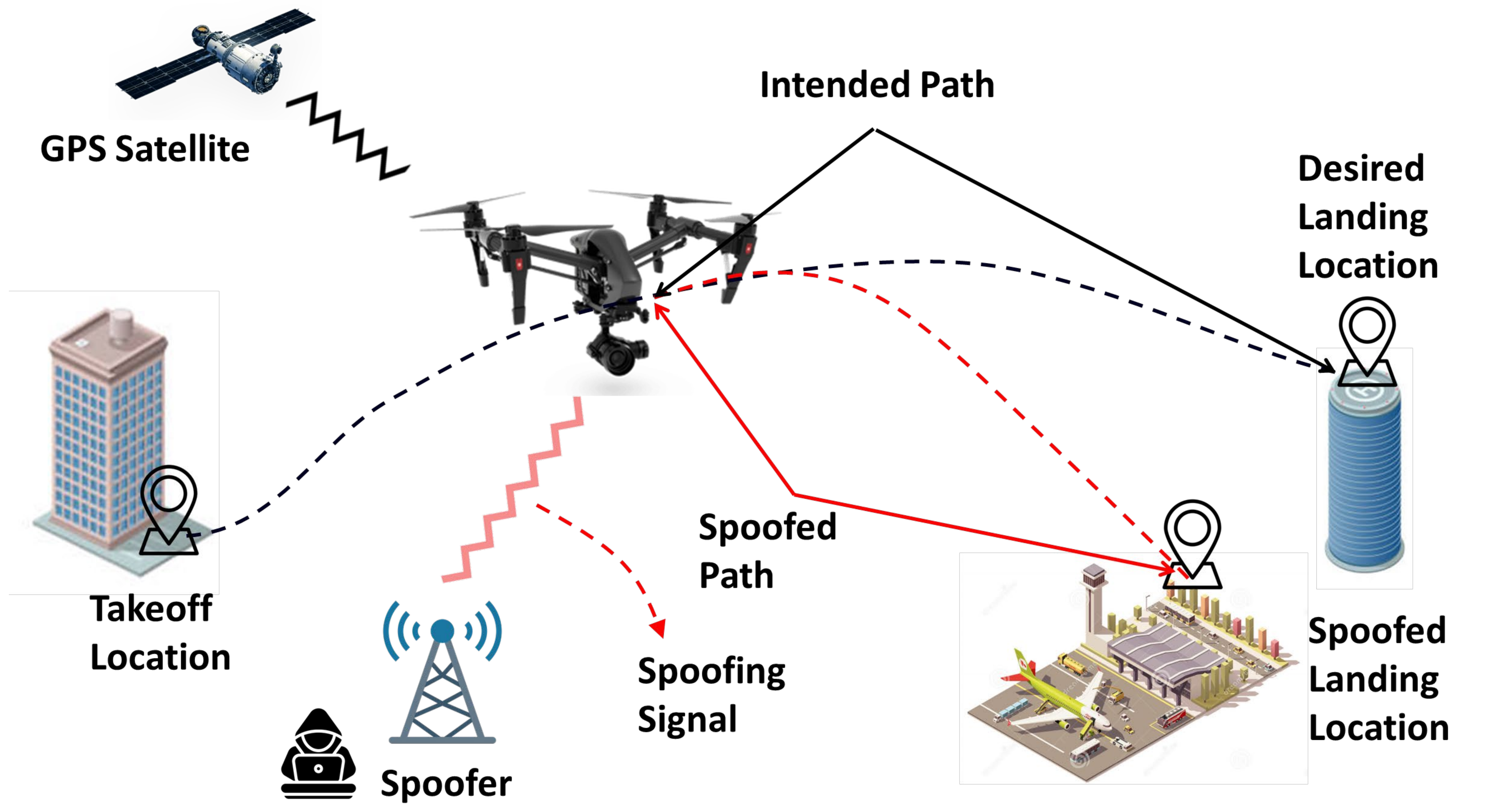
Summary of Dynamical Validation Tests in Simulation Environment

		Roll Axis			Pitch Axis		
		AI FCS	Ref Model	Req.	AI FCS	Ref Model	Req.
Broken-loop Analysis	0dB Crossover Freq (rad/s)	4.556	2.165	> 2 rad/s	2.9176	3.0598	> 2rad/s
	PM (deg)	40.634	46.866	> 45 deg	44.1568	45.636	> 45 deg
	GM (dB)	19.675	13.880	≥ 6 dB	23.2805	10.828	≥ 6dB
Disturbance Rejection	DRP (dB)	3.939	4.435	< 5 dB	3.8222	4.631	< 5 dB
	DRB (rad/s)	1.906	0.820	> 1 rad/s	1.4876	0.854	> 1 rad/s

Handling Quality Levels Level 1 Level 2 Level 3

PM: Phase Margin, GM: Gain Margin, BW: Bandwidth, DRP: Disturbance rejection peak, DRB: Disturbance rejection bandwith, Req.: Requirement

2. AI-aided Visual Inertial Navigation (VIN) for GPS-denied Environments and GPS Spoofing Detection

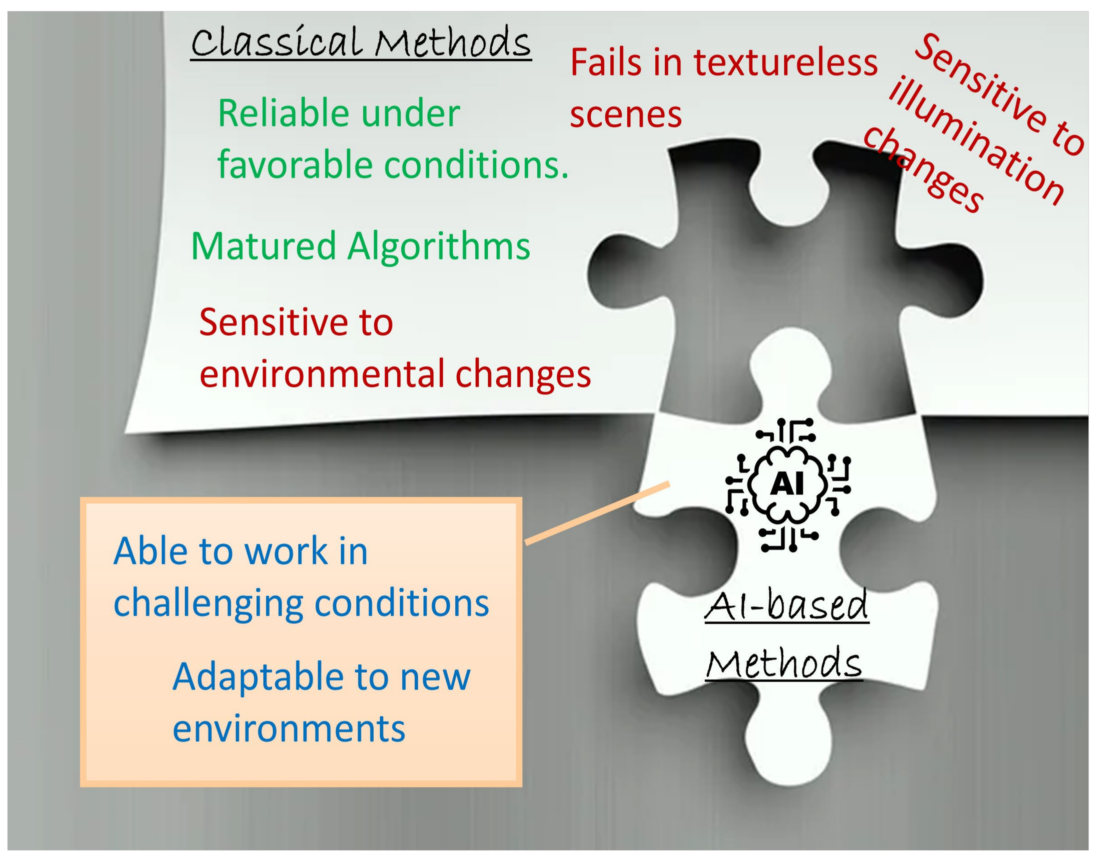


Operations in Urban Airspace

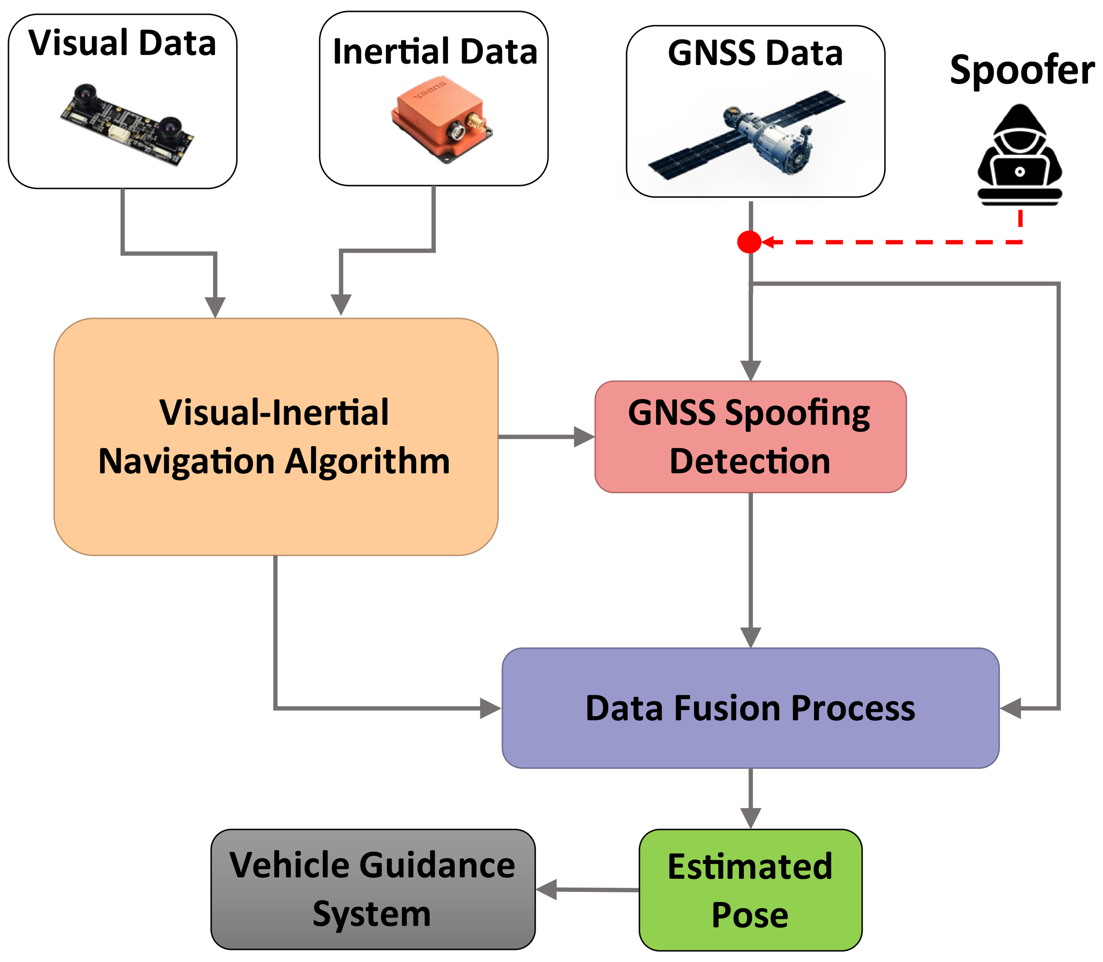
- Require high level of safety
- GNSS is one of the most vulnerable system against cyber-attacks such as jamming and spoofing
- Spoofing attacks are more harmful and difficult to detect
- GNSS system should be supported by utilising multi-sensor pose estimation algorithms not only to detect the attacks but also to provide safety for the vehicle.

Research Proposal

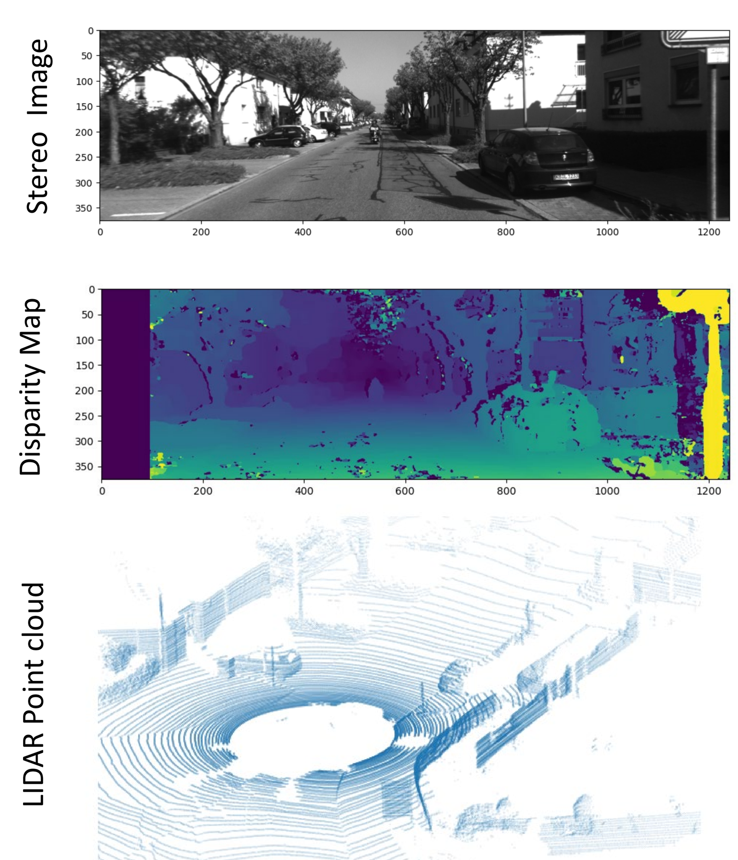
- Designing AI-aided Visual-Inertial navigation system to support the GNSS in the presence of spoofing attacks.
- Combining the AI-based solutions with classical filter-based approach
- Improving pose estimation performance in austere environments



AI-aided VIN System and GPS-Spoofing Detection Overview



Initial Studies by using KITTI Dataset (for ground vehicles)



3. Conclusions

AI-based FCS Design

It is shown that it is possible to integrate handling quality requirements into training process of the AI-based flight control system and validate it by utilizing frequency-domain system identification method.

AI-aided Visual-Inertial Navigation System Design

One of the most dangerous cyber-attacks on autonomous systems in urban environment is GNSS spoofing attack. It is required to support it by utilizing visual-inertial navigation solutions. AI has a significant role to improve the navigation solution accuracy in austere environments and to make the GNSS spoofing detection system more reliable.

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