From Drones to Automated Driving

May 10, 2017 | Motion Control Interface abstraction

Andreas Lindenthal
Technical Director , GENIVI Alliance


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Drones and Automated Vehicles

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Levels of Driving Automation for On-Road Vehicles

SAE International‘s levels of driving automation for on-road vehicles

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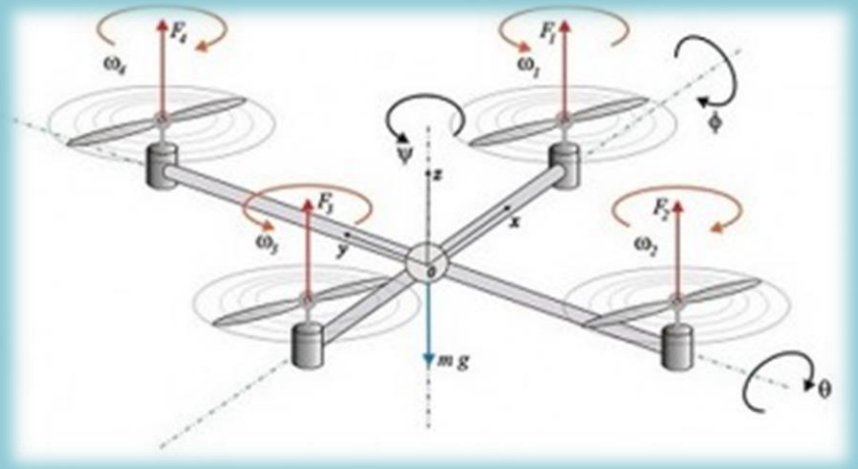
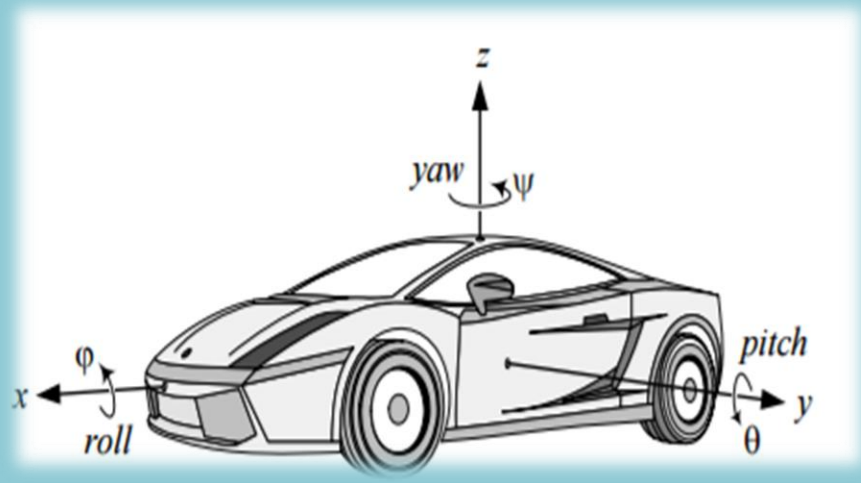
Level	Name	Narrative definition	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fallback performance of *dynamic driving task*	System capability (*driving modes*)	BASt level	NHTSA level
***Human driver* monitors the driving environment**								
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a	Driver only	0
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes	Assisted	1
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes	Partially automated	2
***Automated driving system* ("system") monitors the driving environment**								
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes	Highly automated	3
4	**High Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes	Fully automated	3/4
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**	-	

Vehicle dynamics (simplified models)



Quadcopter



Vehicle

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Degrees of Freedom (DoF)

Vehicle motion (nonholonomic constraint of the road)

- Longitudinal translation (forward backward motion)
- Lateral translation (side slip)
- Vertical translation (bounce or heave)
- Rotation around longitudinal axes (roll)
- Rotation around longitudinal axes (pitch)
- Rotation around longitudinal axes (yaw)

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Degrees of Freedom (DoF)

Drone motion (Quadcopter)

- Longitudinal translation (forward backward motion)
- Lateral translation (side slip)
- Vertical translation (bounce or heave)
- Rotation around longitudinal axes (roll)
- Rotation around longitudinal axes (pitch)
- Rotation around longitudinal axes (yaw)

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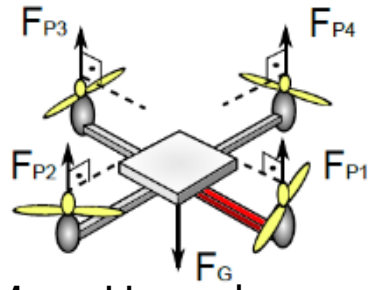
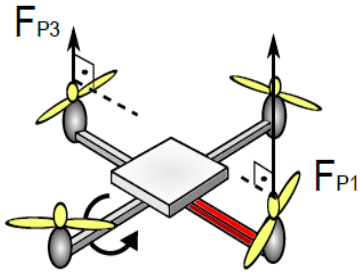
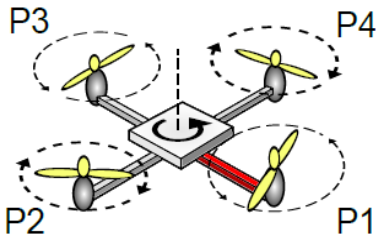
Human Control Interface



Move Up or down

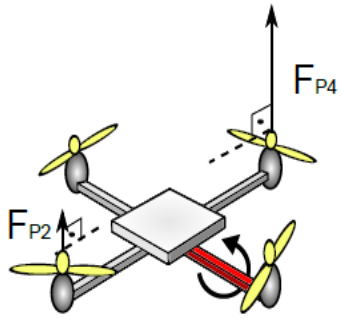


Move Forward or Backward

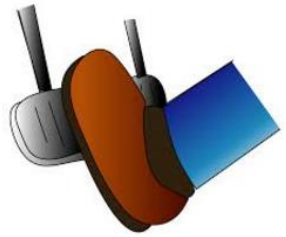


Rotate

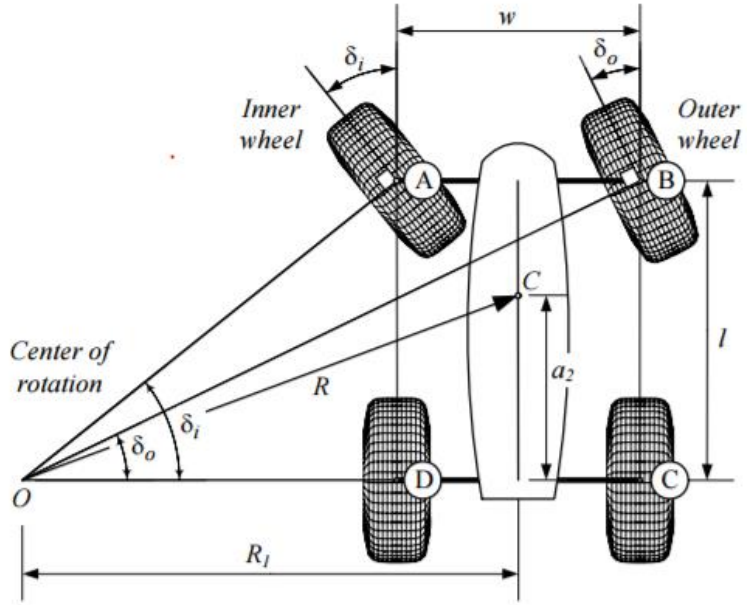
Drive Left or right



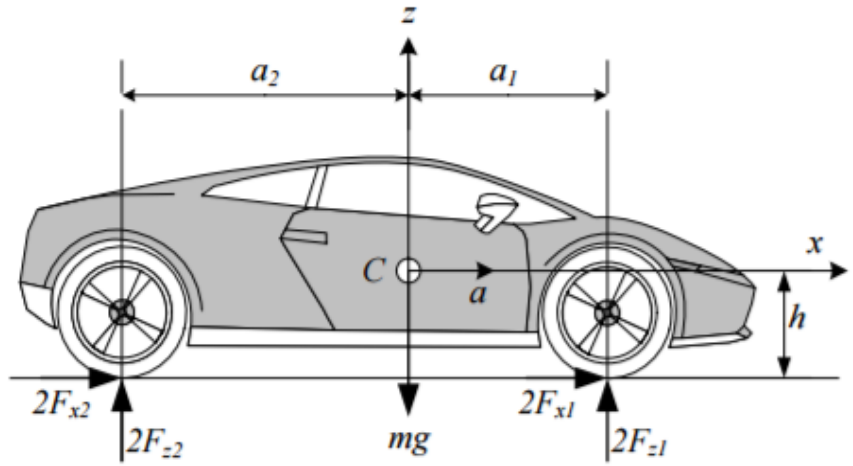
Move Left or right



Drive Forward or Backward



A front-wheel-steering vehicle and steer angles of the inner and outer wheels

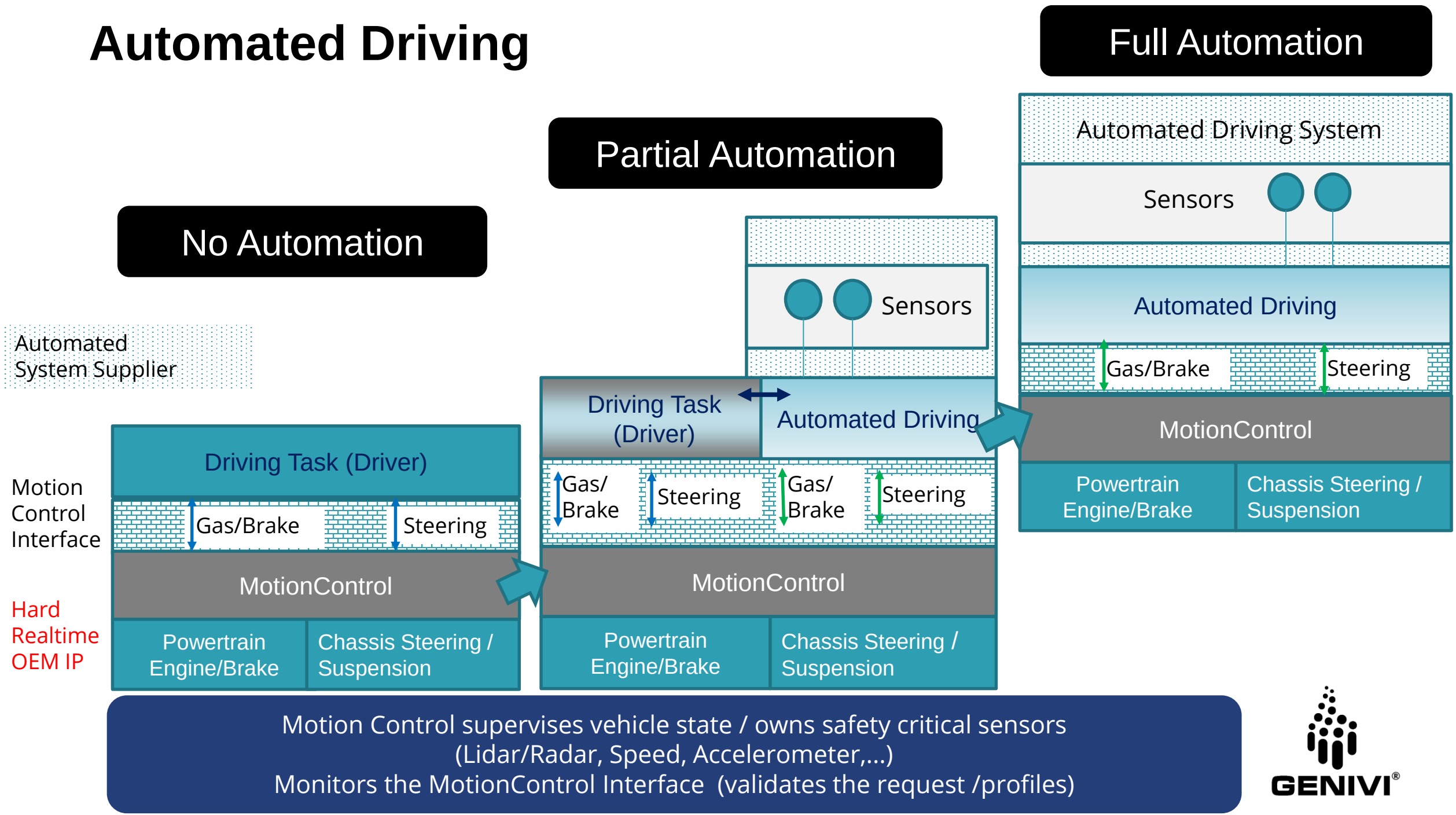


Accelerating car on road

Summary of human motion control interface

- Controls are abstracted
- Controls are aggregated to serve for functions
- Limited aggregated controls are exposed

Automated Driving



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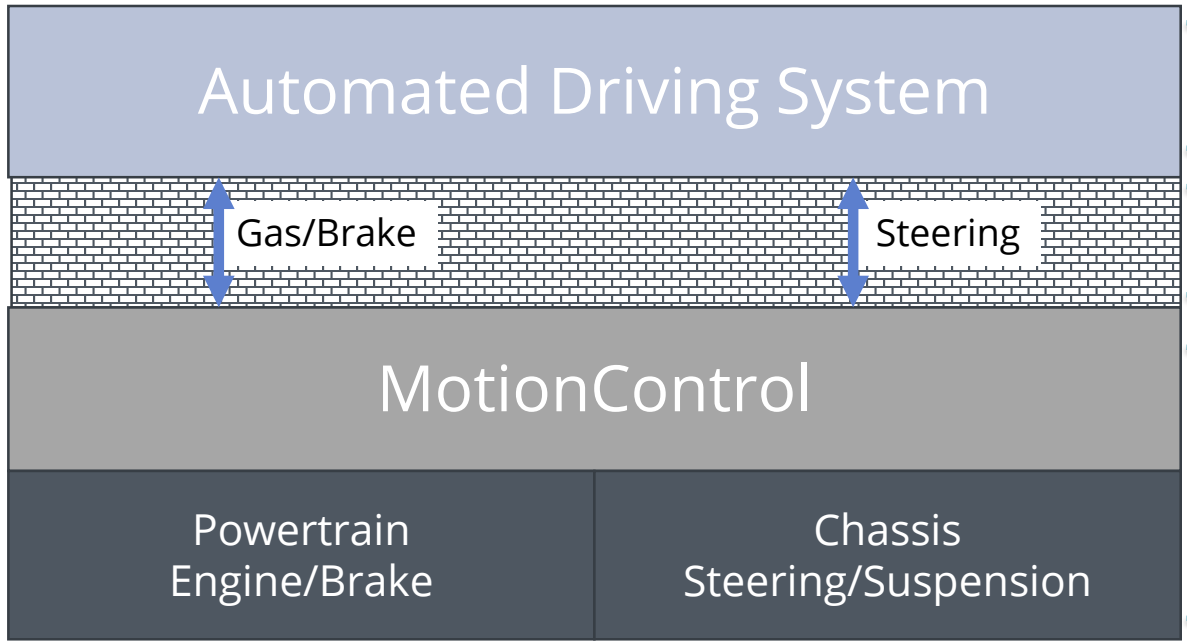
Automated Driving

Motion Control Interface Abstraction



Route/Path/Manoever planing

Target for Abstraction Layer

Emergency break,
Suspension , engine , steering
and braking control

Motion Control supervises vehicle state/ owns safety critical sensors
(Lidar/Radar, Speed, Accelerometer,...)
Monitors the MotionControl Interface (validates the request /profiles)

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Training the Driving task

Record Driving task Videos

Capture Brake/Steering and Gas values

Train a DNN based on this records.

Embedd DNN in vehicle , which is fed with camera input

DNN produces Brake/Steering and Gas values

Feed them into Motion Control Layer

-> DNN- Autopilot

Proposal for GENIVI

- Specify Motion Control
- Provide reference implementation
- Use Genivi methodology (FIDL, Franca,..) for modeling the Motion Control abstraction

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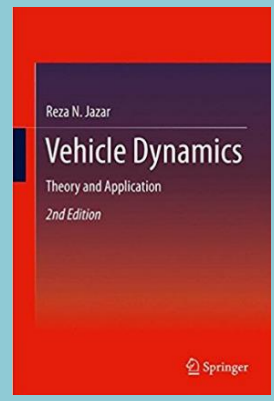
References

- https://theaviationist.com/tag/general-atomics-mq-1-predator/page/5/
- Vehicle Dynamics: Theory and Application



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Thank you!

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Contact us: help@genivi.org