General

<table>
<tr><td>ID[1]</td><td colspan="3"></td></tr>
<tr><td>Use case name</td><td colspan="3">autonomous apron truck</td></tr>
<tr><td>Context</td><td colspan="3">Mobility</td></tr>
<tr><td>Application domain</td><td colspan="3">Embedded systems</td></tr>
<tr><td>Status</td><td colspan="3">PoC</td></tr>
<tr><td rowspan="2">Contributor</td><td>Name</td><td>Affiliation</td><td>Contact</td></tr>
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<tr><td>Scope[2]</td><td colspan="3">Automated transportation of luggage (carts) to requested destinations on an airport apron while following local traffic rules and resolve unplanned conflicts.</td></tr>
<tr><td>Objective(s)</td><td colspan="3">Automate transport to increase reliability, precision, efficiency and safety.</td></tr>
<tr><td rowspan="2">Narrative</td><td>Short description (not more than 150 words)</td><td colspan="2">An AI solution was planned that could operate a luggage truck on an airport apron where it interacts with aircrafts, other machines and humans. It prevents accidents with humans at all times and follows local traffic rules.</td></tr>
<tr><td>Complete description</td><td colspan="2">While the number of airplanes visiting German airports steadily increased over the last decades and recently reached a new all-time high the logistics to enable a smooth processing also increased correspondingly in complexity. To further manage even higher number of airplanes a fully automated luggage truck is developed.

The truck shall receive tasks from a machine or human coordinator and automatically execute these. For specific tasks as loading and unloading or maintenance further interaction with human workers is needed. Therefore the truck is able to communicate its status and intents to surrounding workers.

While operating on the apron the truck shall always obey local traffic rules. The only occasion to violate these rules if an accident is thereby avoided. Human safety is always the truck’s first priority.

For achieving all these functions an AI system consisting of multiple individual elements which all have to operate collaboratively is designed. The three main modules are a perception module, a behavior generator and an execution module.

The truck perceives its environment is by its perception module which consists of multiple submodules, as object detection, recognition, tracking and data fusion blocks for multiple sensor types. The perceived information and their respective uncertainties are further processed to localize, re-project and detect the objects’ intend in the trucks coordinate system.
The perception unit outputs a context model which the behavior generator receives to decide on what actions to take next. This behavior generator consists of a deep reinforcement learning agent and is supervised by a symbolic rule checker to reassure the agent operates fault free. If a taken action violates a rule either the agent has to determine a new action or, in safety critical situations the</td></tr>
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		rule checker determines safe actions by symbolic reasoning. The execution module executes the behavior determined by the behavior generator. It consists of motion planning, control and communication submodules which execute the intended task while reporting back to the behavior generator to react on unexpected situations. Additionally, the trucks status and intends are constantly reported over communication systems to its surrounding to enable uncomplicated interaction with the truck.			
Key performance indicators (KPIs)	ID	Name	Description	Reference to mentioned use case objectives	
	1	Safety	Number of accidents weighted by the level of severity.	Reduce accidents	
	2	Efficiency	The sum of idle time and covered distance.	Improve efficiency	
AI features	Taks(s)	Other (please specify) Sense&Plan&Act			
	Method(s)[3]	Symbolic reasoning & sub-symbolic machine learning & Image Processing, Data Fusion			
	Hardware[4]				
	Terms and concepts used[5]	Computer Vision, Symbolic Reasoning, Deep Reinforcement Learning			
Challenges and issues	Challenges: Achieve at least the same level as human truck operators. Issues: 1) detect other apron traffic participants (especially aircraft) including intentions 2) Multiplicity of various outside conditions (e.g. signs painted on road but ice and snow covering it), and 3) prediction of human behaviour (e.g. workers in reverse walk)				
Societal concerns	Changed work environment for workers during loading/unloading with less interactions with co-workers but more non-social interactions (machines).				

References

References						
No.	Type	Reference	Status	Impact on use case	Originator/ organization	Link
1	Publication	IEEE ITSC 2018: @inproceedings{DBLP:conf/itsc/, author = {Martin Buechel, Alois Knoll}, title = {Deep Reinforcement Learning for Predictive Longitudinal Control of Automated Vehicles}, booktitle = {21th {IEEE} International Conference on Intelligent Transportation Systems, {ITSC} 2018, Hawaii, November 4-7, 2018}, pages = {}, year = {2018}, crossref = {DBLP:conf/itsc/2018}, } (to appear)		Predictive control of the vehicle	fortiss	
	Publication	IEEE ITSC 2018: @inproceedings{DBLP:conf/itsc/, author = {Michael Truong Le, Frederik Diehl, Thomas Brunner, Alois Knoll}, title = {Uncertainty Estimation for Deep Neural Object Detectors in Safety-Critical Applications}, booktitle = {21th {IEEE} International Conference on Intelligent Transportation Systems, {ITSC} 2018, Hawaii, November 4-7, 2018}, pages = {}, year = {2018}, crossref = {DBLP:conf/itsc/2018}, } (to appear)		Estimating the uncertainties of the vehicles sensor processing	fortiss	
	Publication	IEEE ITSC 2018: @inproceedings{DBLP:conf/itsc/, author = {Klemens Esterle, Patrick Christopher Hart, Alois Knoll}, title = {Spatiotemporal Motion Planning with Combinatorial Reasoning for Autonomous Urban Driving}, booktitle = {21th {IEEE} International Conference on Intelligent Transportation		The vehicles motion planning with combinatorial reasoning	fortiss	

		Systems, {ITSC} 2018, Hawaii, November 4-7, 2018}, pages = {}, year = {2018}, crossref = {DBLP:conf/itsc/2018}, } (to appear)				
	Publication	IEEE ITSC 2018: @inproceedings{DBLP:conf/itsc/, author = {Tobias Kessler, Pascal Minnerup, Klemens Esterle, Christian Feist, Florian Mickler, Erwin Roth, Alois Knoll}, title = {Roadgraph Generation and Free-Space Estimation in Unknown Structured Environments for Autonomous Vehicle Motion Planning}, booktitle = {21th {IEEE} International Conference on Intelligent Transportation Systems, {ITSC} 2018, Hawaii, November 4-7, 2018}, pages = {}, year = {2018}, crossref = {DBLP:conf/itsc/2018}, } (to appear)		The vehicles' ability to plan in unknown environments	fortiss	
	Publication	IEEE ITSC 2018: @inproceedings{DBLP:conf/itsc/, author = {Julian Bernhard and Robert Gieselmann and Alois Knoll}, title = {Experience Based Heuristic Search: Robust Motion Planning with Deep Q-Learning}, booktitle = {21th {IEEE} International Conference on Intelligent Transportation Systems, {ITSC} 2018, Hawaii, November 4-7, 2018}, pages = {}, year = {2018}, crossref = {DBLP:conf/itsc/2018}, } (to appear)		Robust motion planning	fortiss	

Footnote

[1] Leave this cell blank.

[2] The scope defines the limits of the use case.

[3] AI method(s)/framework(s) used.

[4] Hardware system used.

[5] Terms and concepts listed here can be used to extend the work of WG 1 (AWI 22989 and AWI 23053) as necessary.

