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# The usefulness of Artificial Intelligence in safety assessment of different transportation modes

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# Objectives

The **objectives of this research** are:

- review the ML and AI methods and approaches used in different transportation modes to solve safety problems

- address research questions:
  - Which AI-related techniques are used in the field of transport safety?
  - Which problems these techniques attempt to address in different transport modes?

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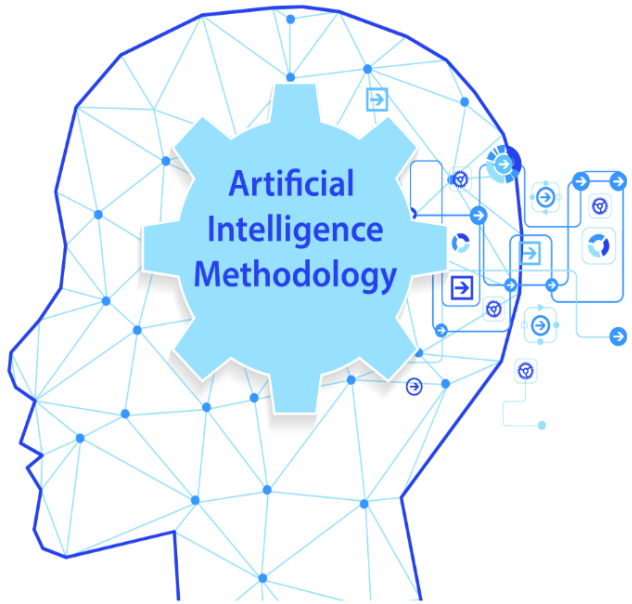
# Methodology

- **Systematic literature review**
  - definition of the research questions
  - the identification of search string(s)
  - the selection of the sources and search engines, study selection criteria
- **Search strings**:
  - safety, transport, road, rail, maritime, aviation, artificial intelligence, machine learning
- Searched in a large set of scientific peer reviewed Journals and Conferences contained at the Science Direct, Scopus and Google Scholar databases
- Papers published after 1995
- **50 papers were reviewed**

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# What is Artificial Intelligence (AI)?

- The theory and development of computer systems able to perform tasks **normally requiring human intelligence**, such as:
  - visual perception
  - speech recognition
  - decision-making
  - language translation

- AI leverages computers to **imitate the problem-solving and decision-making** capabilities of the human mind.

- **Popular AI/ ML techniques**:
  - Classification
  - Clustering

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# Why now?

- Increased **computing power**
  - cloud computing
- **Rapid technological progress** especially in telematics, Internet of Things (IoT), Internet of Vehicles (IoV) and Big Data (BD) analytics
- Technological advances in **sensor devices** (smartphones, autonomous vehicles (AV) etc.)
- Many data collected nowadays
  - chaotic to manage
  - only AI can exploit them


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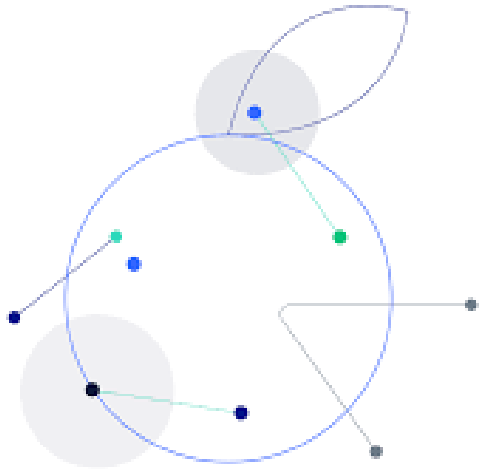
# Past and future safety models

- Historically, safety models were developed based on **collision records** stored in databases
- Mainly **statistical and econometric analysis** of past accidents
  - inability to prevent accidents in real-time
- Recent interest in safety analysis and collision models is based on **real-time observations** of collisions and interactions
- AI and advanced computing techniques are particularly suited to:
  - **mine** the data
  - **train models** from the data
  - find **associations**



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# AI in different transport safety fields

| Transport safety fields | Type of AI technique | | | | |
|---|---|---|---|---|---|
| | Incident Detection | Crash Prediction | Defect Detection | Surveillance | Assistance |
| Road | | | | | |
| Rail | | | | | |
| Maritime | | | | | |
| Aviation | | | | | |

Which are the common areas and methods?

*AI is used in all transport safety fields without noticeable transfer of knowledge among them*

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# Road – Key findings

- **Incident detection**
  - multi-layer feedforward neural networks for incident detection in freeways (Dia & Rose, 1997)
  - semi-naïve Bayes classification model to classify tweets as either traffic or non-traffic incident (Gu et al., 2016)

- **Crash prediction and pattern identification**
  - long short-term memory model with spatiotemporal correlations to predict traffic accident risk (Ren et al., 2018)
  - mathematical optimization to discover driving behavior patterns and create groups of drivers (Tselentis et al., 2019)

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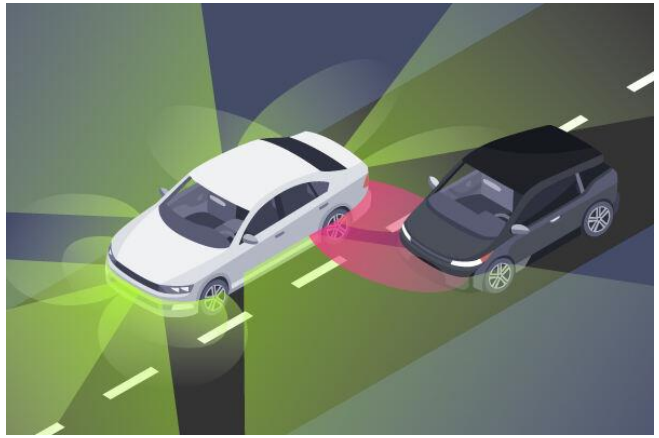
# Road – Key findings

- **Autonomous vehicles (AVs)**
  - Convolutional Neural Networks for the recognition of pedestrian movement direction (Dominguez-Sanchez et al., 2017)
  - A combination of Principal Component Analysis, Support Vector Machines (SVM) and a NN-based classifier for pedestrian detection and canny edge detection for traffic lights (Jeon et al., 2016)

- **Advanced driver-assistance systems (ADAS)**
  - Decision-tree and a Bayes model for lane changing prediction (Hou et al., 2013)
  - Multi-Layer Perceptron Neural Network model to develop a system for real-time collision warning (Lee & Yeo, 2016)



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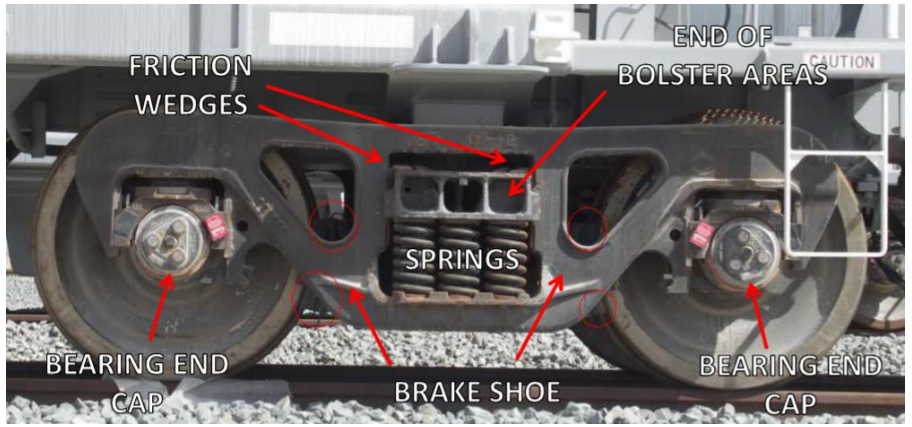
# Rail – Key findings

- **Defect detection**
  - A combination of a traditional object localization and Convolutional Neural Network (CNN) model for rail defect detection (Shang et al., 2018)
  - SVM and CNN tested for wheel defect detection (Krummenacher et al., 2017)




- **Obstacle detection**
  - Adaboost algorithm thermal camera data to detect obstacles in level crossing and calculate distance between obstacles and the train (Manikandan et al., 2017)
  - Fast Region-based CNN to detect people, trains and animals ahead (Yu et al., 2018)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# Maritime – Key findings

- **Maritime Surveillance**
  - CNN models using super resolution satellite data to enhance vessel detection, counting and recognition for maritime surveillance (Fontana et al., 2020)
  - CNN-based framework to improve visual recognition, focusing on the classification and identification of maritime vessels (Solmaz et al., 2018)

- **Incident Detection**
  - Bayesian networks for anomaly detection in vessel tracking (Handayani & Sediono et al., 2015)
  - SVM as a pattern classification technique for anomaly/ incident detection (Handayani et al., 2013)

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# Aviation – Key findings

- **Incident Diagnosis**
  - Probabilistic Neural Network for engine health assessment using on-wing engine data (Aretakis et al., 2015)
  - Random Forest model for real-time turbulence forecasting (Williams, 2014)

- **Flight assistance**
  - Genetic algorithm that generates trajectories of specified length for the on-board flight path safety system (Kulida & Lebedev, 2017)
  - Dual fuzzy neural network controller to develop an intelligent landing control system for civil aviation aircrafts (Xu et al., 2011)

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# Summary of results

## Number of papers per transport safety field that used each AI and ML methodology

| | Type of AI technique | Classification | | | | | | | | | Clustering | | Regression | | Optimization | Dimension reduction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mode** | Transport safety field | ANN | SVM | Bayesian | HMM | kNN | Decision tree | AdaBoost | Maximum likelihood | Wavelet transform | K-medoids | a-priori | ANN | Multiple regression | Optimization | PCA |
| **Road** | Incident Detection | 2 | 1 | 1 | 1 | 1 | | 1 | 1 | | | | | | | |
| | Crash Prediction | 2 | | | | | | | 1 | | 1 | 1 | 4 | 1 | 1 | 1 |
| | AV and ADAS | 6 | 3 | 1 | | 1 | 1 | | | | | | | | | 1 |
| **Rail** | Defect Detection | 2 | 1 | | | | | | | 1 | | | | | | |
| | Obstacle Detection | 2 | | | | | | 1 | | | | | | | | |
| **Maritime** | Maritime Surveillance | 2 | | | | | | | | | | | | | | |
| | Incident Detection | | 2 | 4 | 1 | | | | | | | | | | | |
| **Aviation** | Flight assistance | 2 | | | | | | | | | | | | | 1 | |
| | Incident diagnosis | 1 | | | 1 | | 1 | | | | | | | | | |

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# Conclusions

- Most transportation safety fields are formulated and resolved as **classification problems**

- **Artificial Neural Networks** are the most commonly used AI methodologies
  - high modelling performance especially in image processing
  - **SVM, HMM and Bayesian** models are also used in most transport modes and mainly for incident detection purposes

- A **wider variety of methodologies** is observed in road transport
  - more studies and data available

- The choice of AI technique is mainly driven by the **purpose of the safety analysis**
  - e.g. the characterization of an object as obstacle or not is usually formulated as a classification problem → use of an ANN, SVM etc. algorithm

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# Main applications of AI in Transport Safety

- Driver safety monitoring and behavioural assessment through smartphone app
- Development of driver assistance systems to improve safety
- Safe navigation of different transport modes (AVs, Vessels, Aircrafts)
- Detection of rare conditions (road, weather, incidents etc.)


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# Challenges

- Data collection size
- Representativeness of the data sample
  - Train autonomous vehicles/ vessels on all possible external and environmental conditions
- Cyber security issues
- Reduce the number of collisions caused while moving to the autonomous era
  - no widely accepted and agreed basis yet to ensure that the AI algorithms used in the vehicles are safer than humans


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