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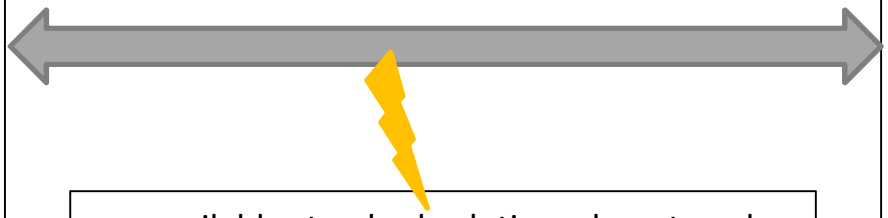
Success factors for digitalization in logistics

(empirical) insights, guidelines and (research) framework
…and some inspiration

Introduction

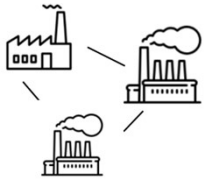
- logistics/ supply chain management as crucial for competitiveness
- Continuously increasing complexity
- Logistics systems need to fulfil high requirements: need for quick-response and efficient processes



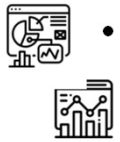
- technological innovations offer huge potential
- IoT, CPS, AI, 3D Printing, …
- Research programs, public funding

- available standard solutions do not apply to every sector
- no “off-the-shelf" solution
- holistic perspective is needed
- Esp. SMEs are challenged … lack of resources, deficits in strategic thinking, individual infrastructure, limited adaptability

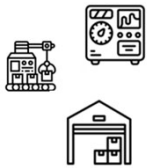
Potential of CPLS



Communicating competencies/ abilities
Finding optimal network configuration



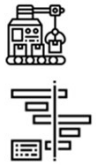
- Generating demand forecasts



- Analyzing availability
- Collecting and evaluating proposals
- Analyzing inventory levels

- Schedule orders
- Retrieve and provide goods

- Optimize routes
- Pool transportation quantities
- Optimize utilization
- Load vehicles



- Configure equipmemt
- Optimze sequence and allocation

- Collect and evaluate disturbances and changes
- Monitor progress, adapt capacities, sequence etc.

Icons from www.flaticon.com

AI Potential

- Prediction of consumer trends
- Automation of product movements
- Optimization of transportation routes
- Pattern recognition, e.g. quality control
- Clustering (markets, articles)
- Forecasting of disturbancies
- Prediction of machine conditions
- AGV orchestration
- (semantic) Interpretation of data
- …

Application area	**Potential**
Asset Performance management	34% less downtime, 10% reduced maintenance costs
Process & quality improvement	25% more productivity, 5-20% reduced labour costs QC
Resource optimization	10% better compliance with safety regulation
Supply chain optimization	10% lower supply chain costs, 20% inventory reduction

IBM 2018

(Research) Questions

- How can new technologies (I4.0, IoT, AI) be selected and applied **expediently** in logistics systems?
- What is the **contribution of human participants** and how are they (should they be) involved?
- What **preconditions** are necessary at company level?
- How can the necessary **data** be collected/ provided at a necessary quality level?

Decision making

- process of selecting the course of action that best meets the decision criteria w.r.t the inherent constraints of the situation

intelligence phase	• problem which requires a solution by the decision-maker is identified and prioritized • target achievements are defined, corresponding data gathering is initialized
design phase	• general action plan, which contains action alternatives and their expected outcomes as well as evaluation criteria, is defined
choice phase	• decision-maker selects the best action alternative based on the evaluation of each alternative

Human decision making

…is very special

- opportunistic procedures
- no careful analysis of the goals, tasks, constraints
- assumptions and opinions serve as planning information
- risk tendency
- “muddling through”
- influenced by the actual level of subjective control and emotional processes
- self-efficacy
- ‘Encapsulation’ (avoid problematic fields of action and concentrate on aspects where great skills and competencies exist)
- tendency to use mental models that are too simple for the adequate description of actual problems
- …

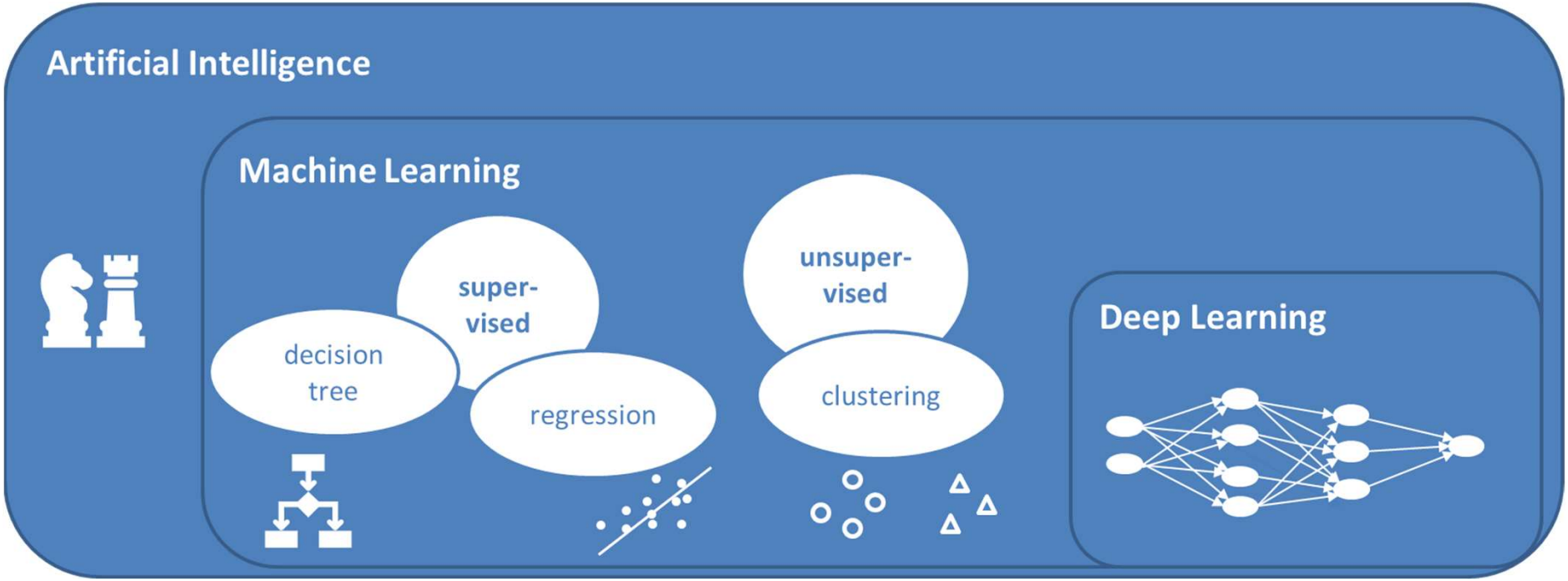
Riedel, Starker, von der Weth, 2014

https://www.potential.com/

https://cmoe.com/blog/managers-must-effective-problem-solvers/

- Memory biases (availability heuristic, imaginability bias)
- Statistical biases (correlation bias, gambler’s fallacy)
- Confidence biases (illusion of control or overconfidence biases, confirmation bias)
- Adjustment biases (anchoring effect, conservatism bias)
- Presentation biases (ambiguity effect, primacy/recency effect)
- Situation biases (complexity effect, ostrich effect, bandwagon effect)

AI for decision-support in smart logistics systems



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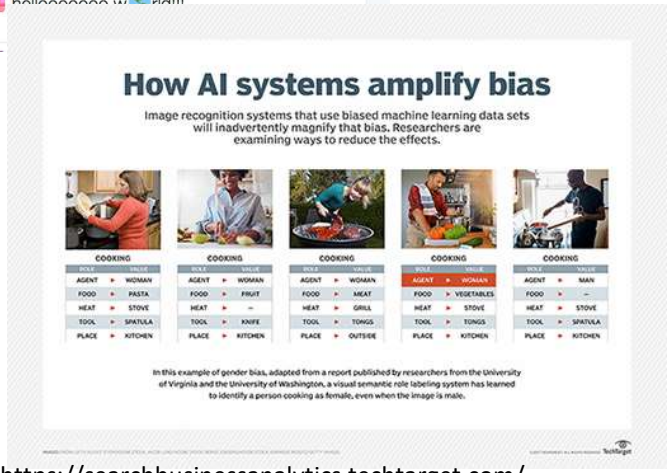
AI shortcomings

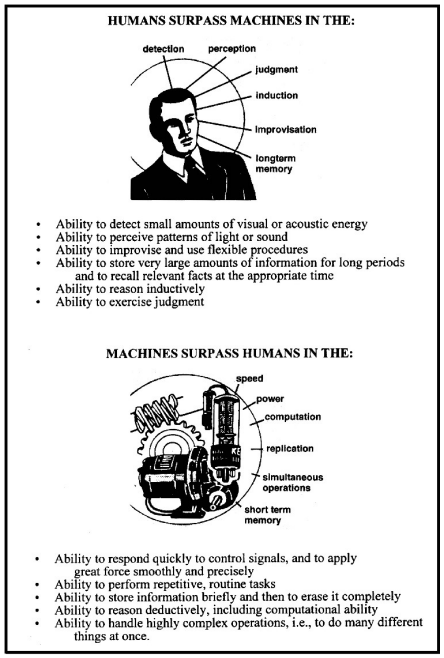
- biases
- learning based on Big Data, no implicit learning
- no holistic experience, which limits understanding
- no generalization and no transfer to different contexts
- correlation ≠ causality
- no out of the box thinking, lack of creativity
- no strategic approach
- no emotions/ no ethical evaluations
- high computing power needed for complex problems
- results depend on data quality and availability

https://www.zeit.de/



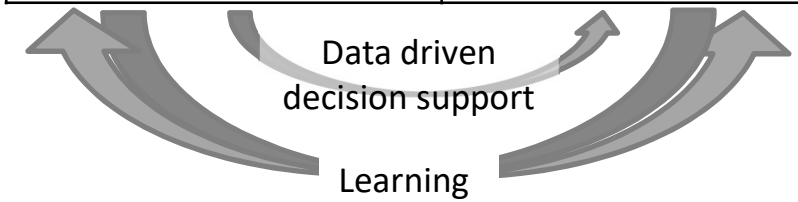
https://searchbusinessanalytics.techtarget.com/

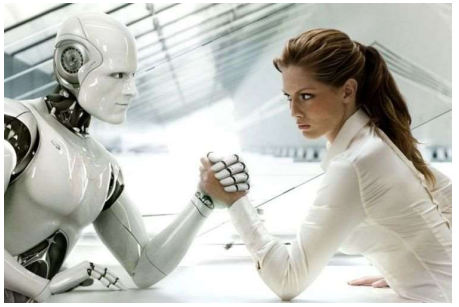
Task allocation



Bradshaw et al. 2012

AI	Humans
• Analysis of big data • Pattern recognition • Classification • Text analysis • Forecasting • Optimization • Repetitive, rule based tasks	• Definition of strategies and goals • Interpretation • Handling of exceptions • Creative tasks





https://www.pinterest.ch/pin/484840716114981085/

Task allocation: Design imperatives

- Tasks must be designed in a way that is conducive to health and learning.
- AI technology should take over monotonous human tasks, but not those that are motivating and personality-enhancing
- AI automation must be designed in a way that supports rather than burdens employees.
- Design solution must
  - create enough control opportunities
  - ensure opportunities to enhance control skills
  - convey meaning and goals to generate motivation
- Dynamic developments (learning) and context (situation, disposition & motivation) must be considered.

+

Technically:

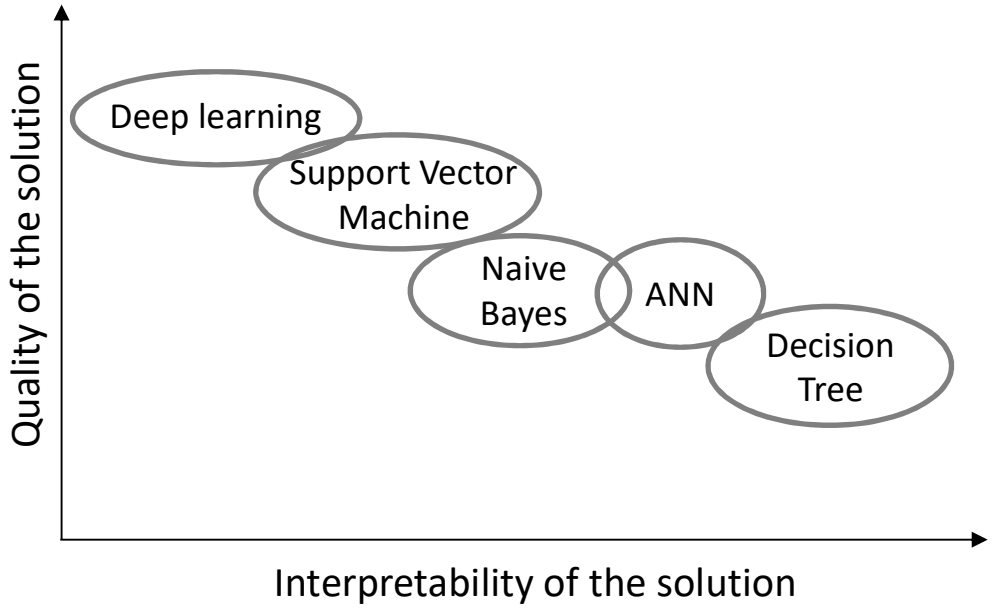
- Explainability, transparency
- Data sovereignty
- Data quality
- Robustness
- Validity
- Verifiability

Evaluation of AI methods

Description	Advantages	Disadvantages	Typical applications
Linear regression			
finds linear representation of data points	easy to interpret	not suitable for complex data	trends
	allows easy detection of important variables	tendency of overfitting (i.e. adapting too strongly to the training data)	forecasting
			quality optimization
Logistic regression			
identifies nonlinear relationships or classification	easy to interpret	not suitable for complex data	detect occurrence-influencing aspects
	efficient to train	tendency of overfitting	
Decision tree			
branching in order to gradually generate a classification	provides explanation for classification	not suitable for complex data	characteristics classification, e.g. reject/no reject
			fault diagnosis
k-means			
iteratively refined assignment of data to clusters	broadly applicable (easily adaptable)	not suitable in combination with outliers	image segmentation
	guarantees convergence	number of clusters as input data	
Neural networks			
combinations (in form of weighted sums) of information	suitable for very complex data	more difficult to train	fault diagnosis
		results are usually not interpretable	forecasting

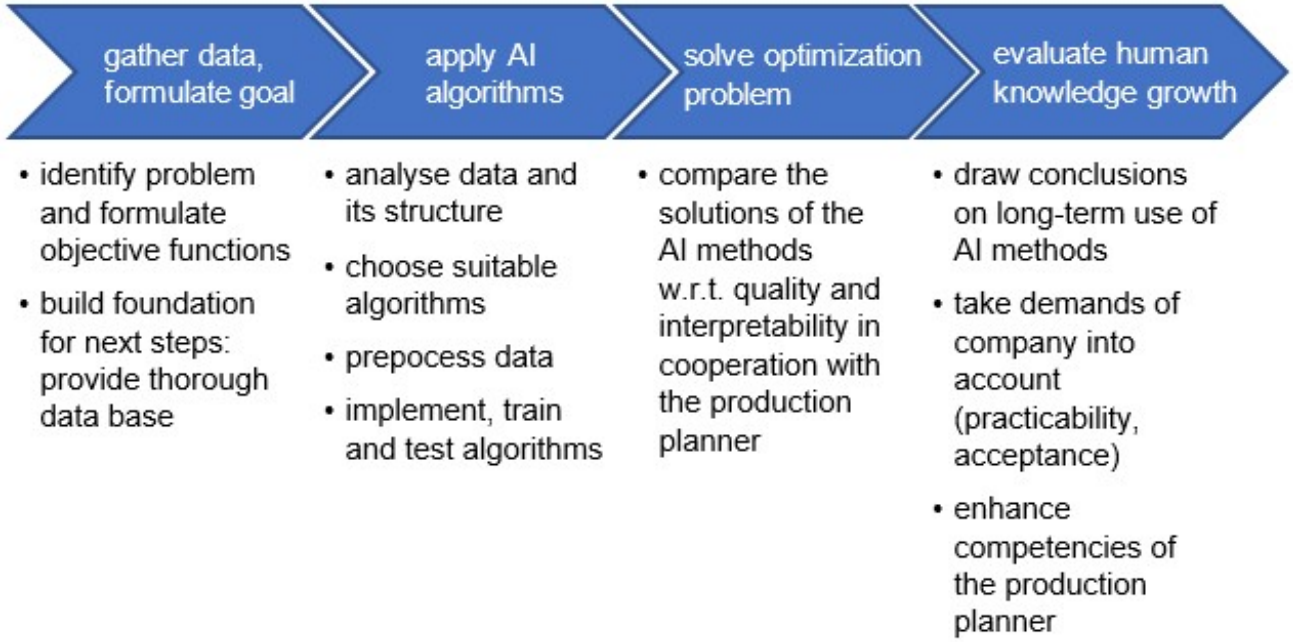
Schumann, Riedel, Franke, Nitsche & Runte, 2022

Evaluation of AI methods



Franke, Franke & Riedel, 2022

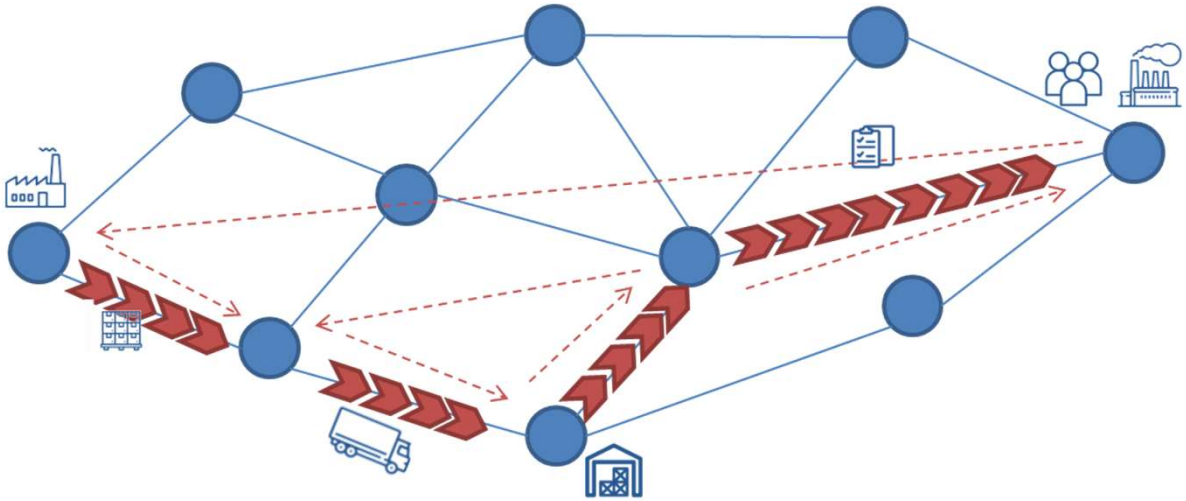
Evaluation of AI methods



Franke, Franke & Riedel, 2022

Framework for decision-support

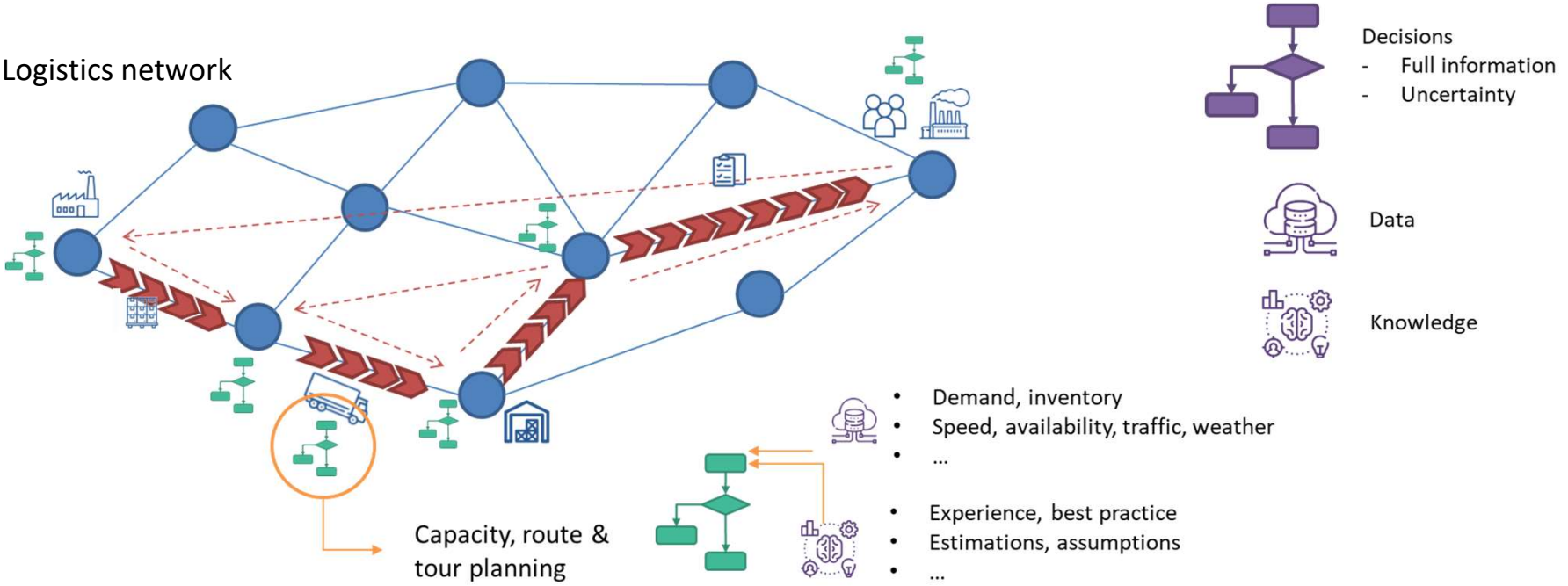
Logistics network



Schumann, Riedel, Franke, Nitsche & Runte, 2022

Icons from www.flaticon.com

Framework for decision-support



Schumann, Riedel, Franke, Nitsche & Runte, 2022

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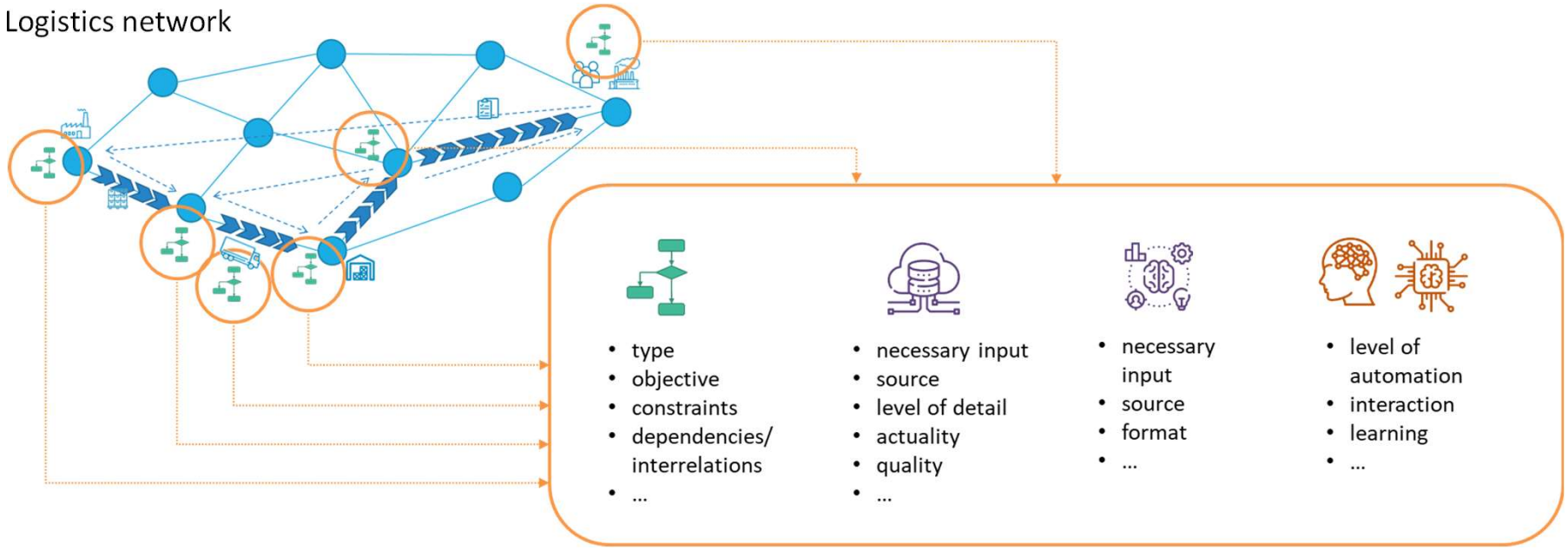
Framework for decision-support



Schumann, Riedel, Franke, Nitsche & Runte, 2022

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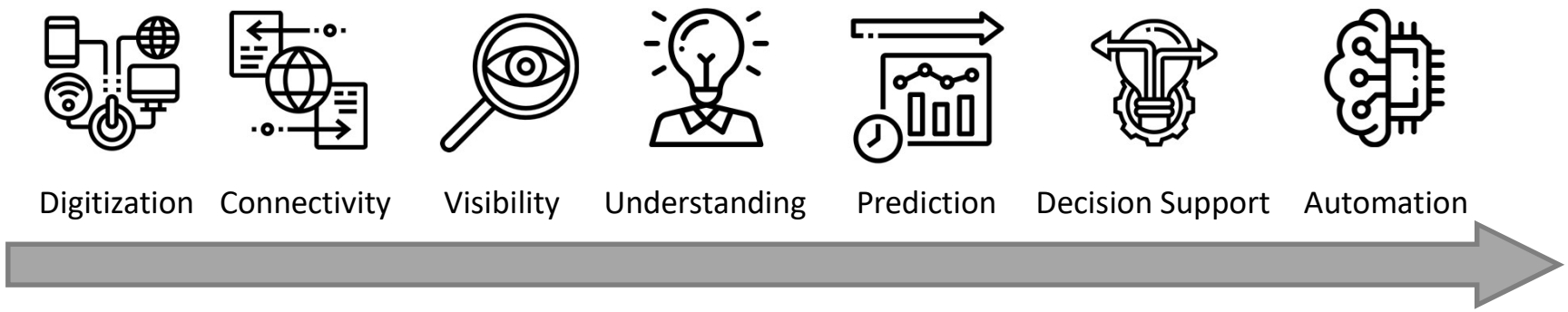
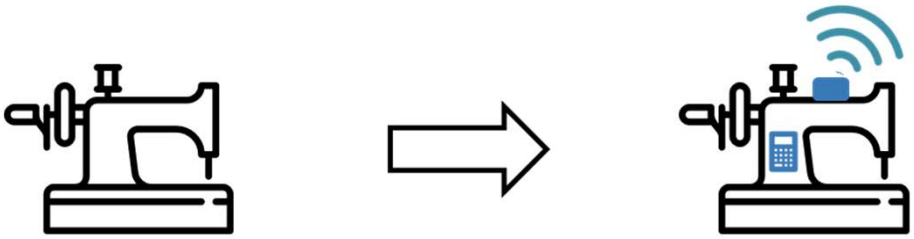
Decision-support in logistics systems



Icons from www.flaticon.com

Data acqusition: Retrofit process

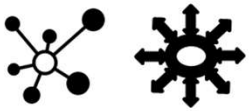
- retrofit process



- digitization before digitalization

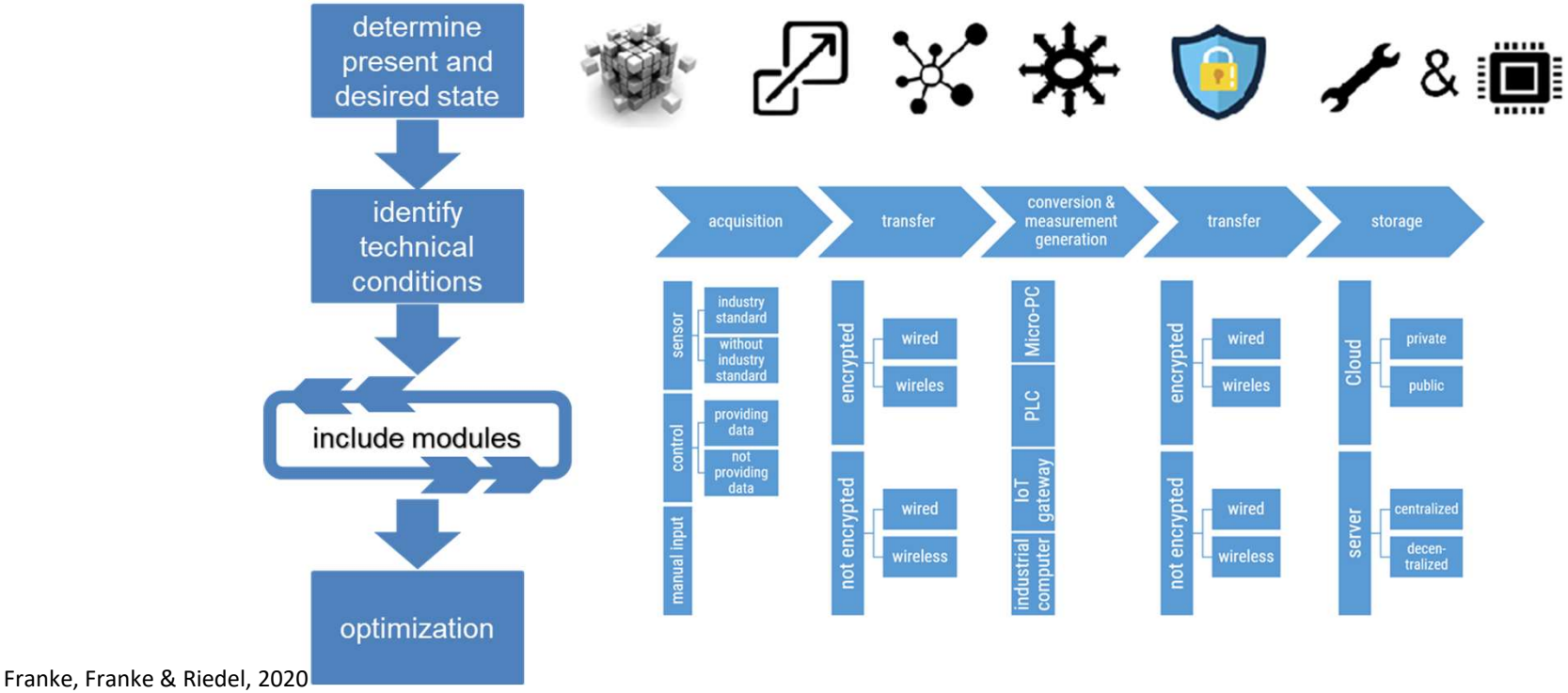
Franke, Franke & Riedel, 2020

Requirements for retrofit

	Requirement	Description
	Modularity	separability and functional independence
	Scalability	ability of a system to accommodate an increasing number of elements or objects and/or to be susceptible to enlargement
	Open interfaces	ability to include data from various sources and combines them into a consistent system
	Data security	set of standards and technologies that protect data from intentional or accidental destruction
	Technical flexibility	including both easy in-house developments and highly advanced, industry-standard solutions

Franke, Franke & Riedel, 2020

Retrofit project



Franke, Franke & Riedel, 2020

Data acquisition

Criteria

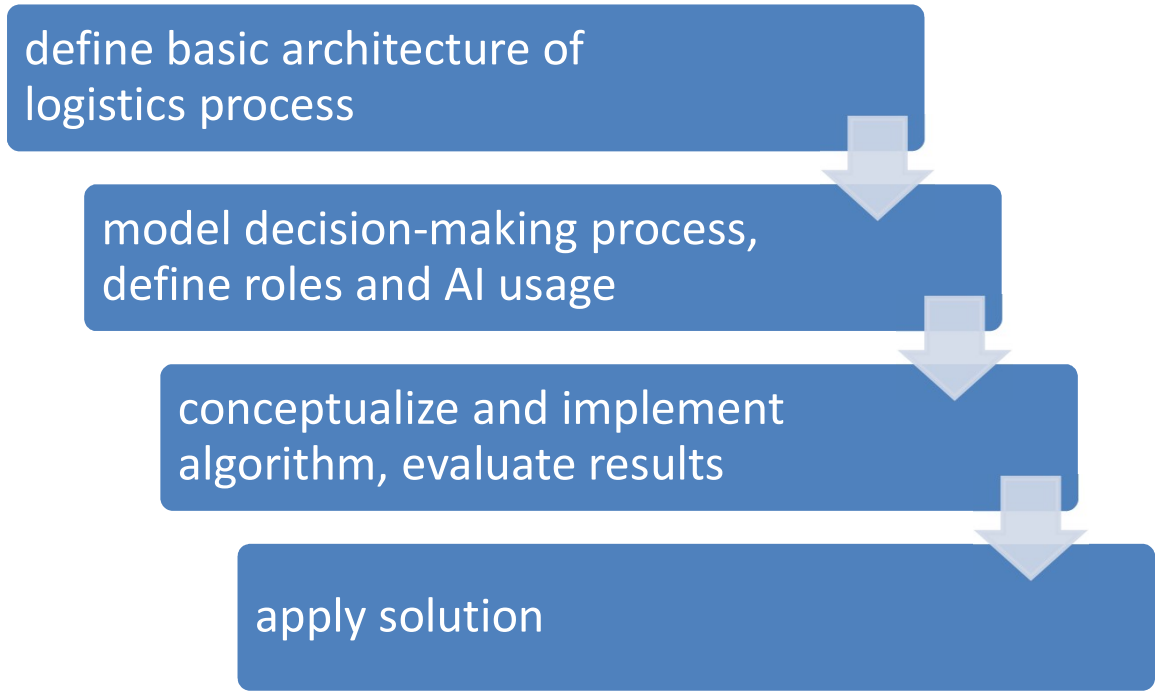
- resolution (granularity, frequency)
- integration (combination of multiple sources or availability of different sources to achieve a certain goal)
- generalisability
- operationalisation (complexity and accessibility to resources)
- means (e.g. type of sensor, manual input using which type of HMI, …)
- transferability
- necessity (satisfaction of operational performance indicator)
- costs
- integration

Data Quality Dimensions

- Completeness
- Uniqueness
- Correctness
- Actuality
- Accuracy
- Consistency
- Freedom from redundancy
- Relevance
- Uniformity
- Reliability
- Comprehensibility

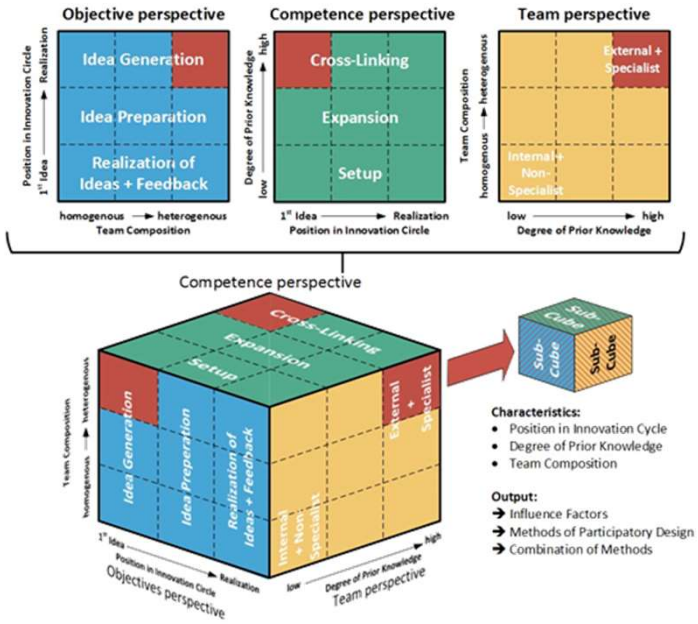
Icons from www.flaticon.com

Implementation



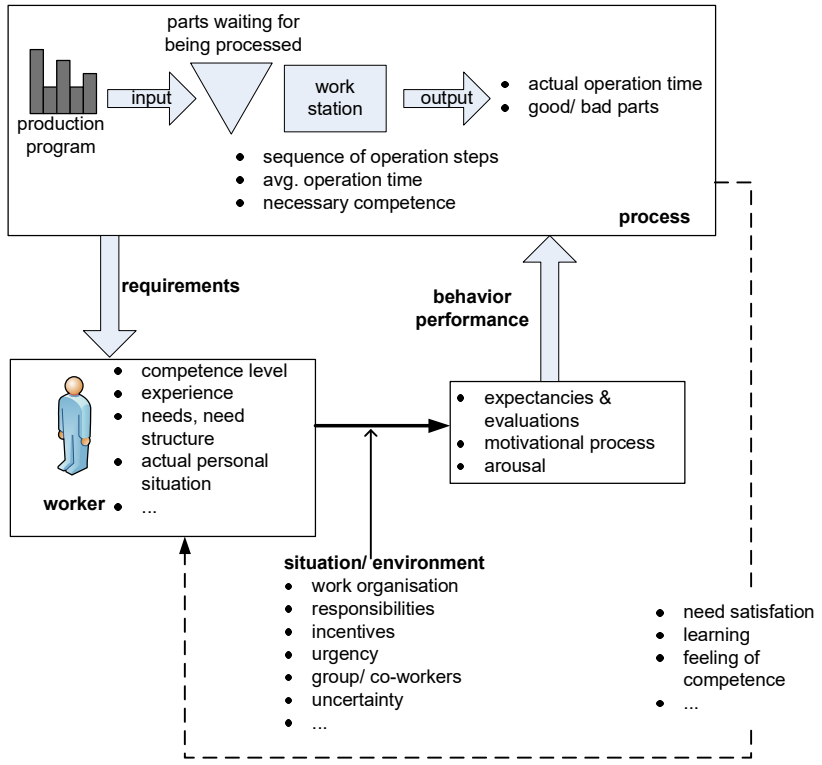
Schumann, Riedel, Franke, Nitsche & Runte, 2022

Implementation



Bojko, Riedel & Tawalbeh, 2019; Chen, Riedel, Bojko, et al., 2018; Tawalbeh, Riedel et al., 2018; Jentsch, Riedel & Müller, 2013; Tröger, Jentsch, Riedel & Müller, 2011; Schulz & Riedel, 2008

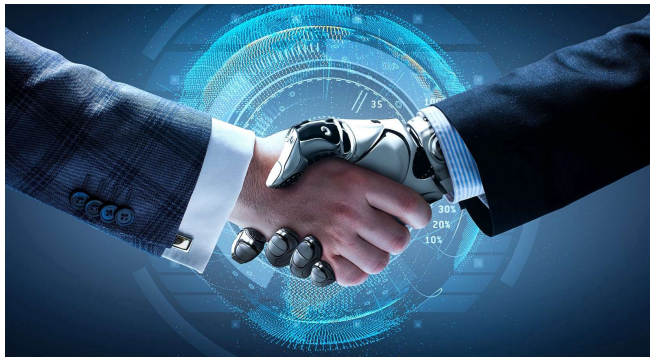
In progress: modelling approaches



Riedel, Starker, von der Weth, 2014; Riedel, Müller, von der Weth, Pflugradt, 2009; Mach, Kreusslein, Schmalfuss, Bojko, Riedel, Beggiato, Krems, 2019

Conclusion

- Complexity, dynamics, uncertainty will continue to increase
- Technological solutions are indispensable - humans are indispensable as well
- Human-centered design solutions are necessary to unleash the potential of both – in a joint/ cooperative manner
- Proper analysis of the target and actual state is decisive
- Model of system‘s architecture and decision-making process needs to be built
- solution needs to be tailored to decisions, preconditions and situations
- Collaboration and participation is key
- Solutions should strive for including and enhancing knowledge of human decision-makers



https://becominghuman.ai/ai-the-future-of-work-a90b1438cc5b

Questions for further research

- How much and which knowledge is necessary that AI works?
- How can this knowledge be acquired, described, stored and made accessible?
- How can relevant tasks, situational und personal parameters be captured and modelled?
- What are the “right” evaluation criteria for task allocation?
- How must AI support be designed to be accepted by and to be helpful for workers?
- …

https://hmi.anu.edu.au/

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