Challenges in Developing Requirements for AI-based Systems: A Systems Engineering Perspective

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Introduction to AI-based Systems

- **AI-based systems**
  - Software and/or Hardware systems.
  - Data-centric
    - ✓ During development and/or deployment
  - Rule-based, algorithmic, heuristics, etc., to exhibit intelligence.
  - Several vague, quality attributes
    - ✓ Explainability, privacy, ethics, resilience, etc.

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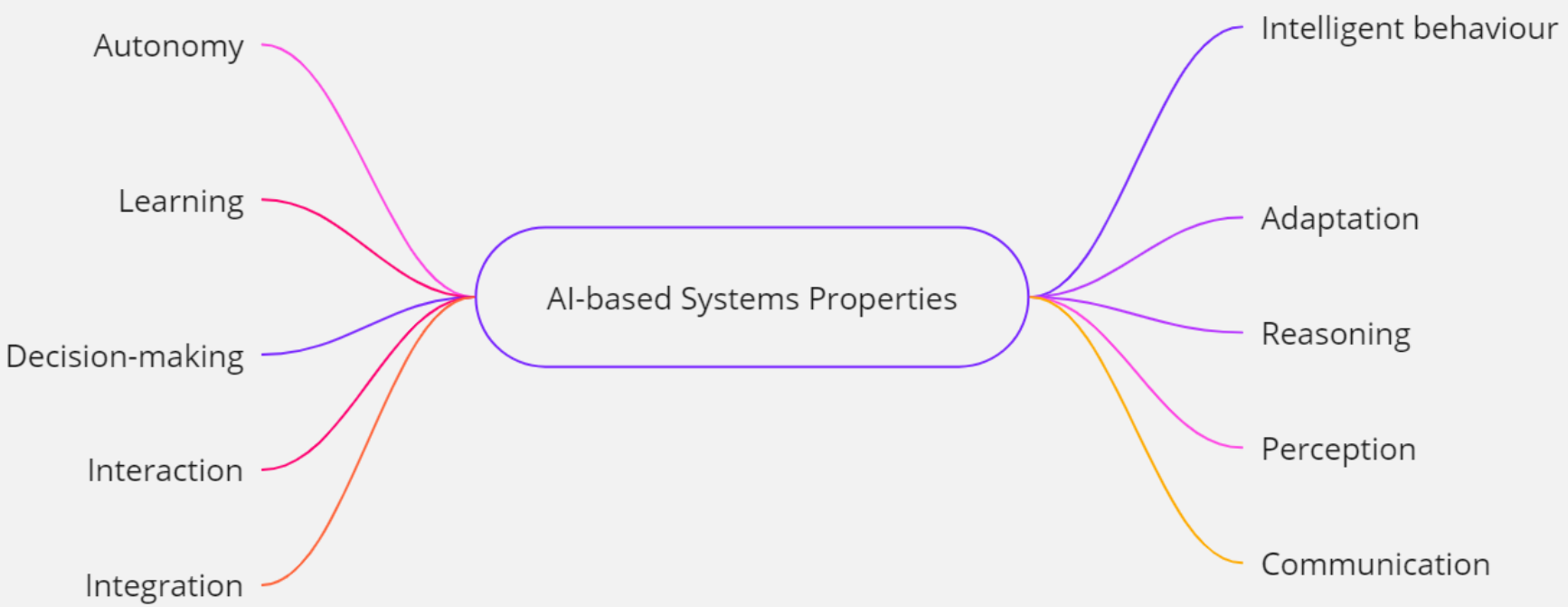
Characteristics of AI-based Systems



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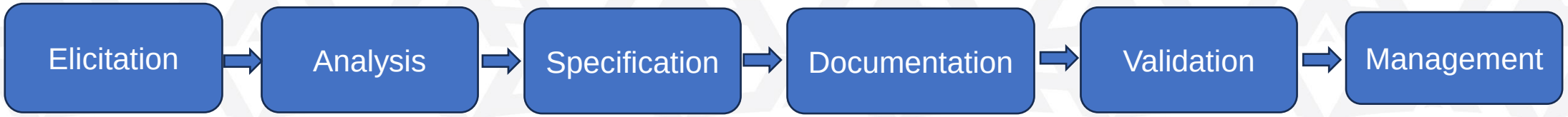
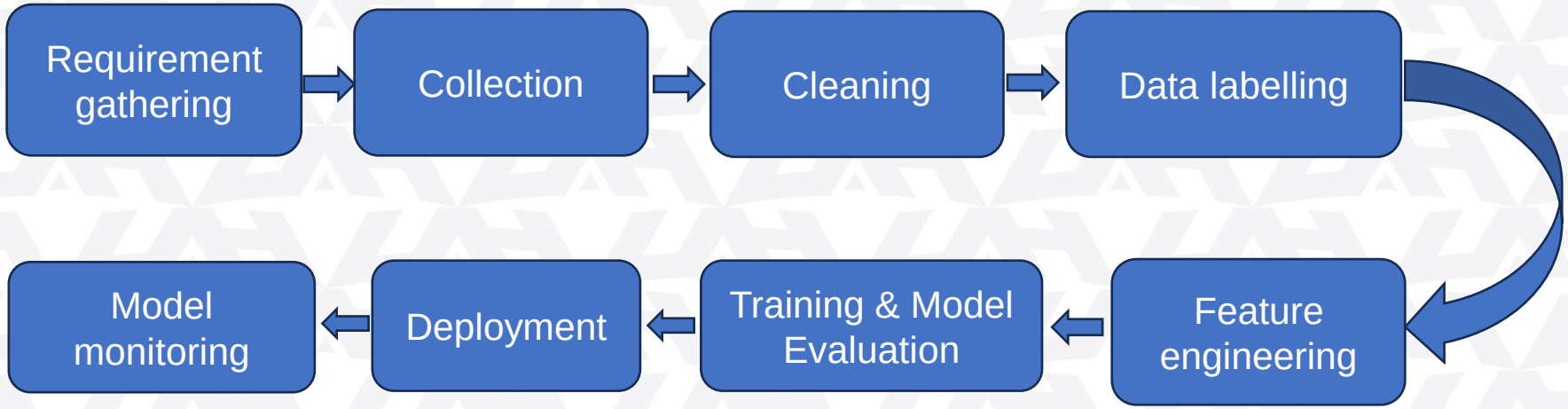
Requirements Engineering

❖ Requirement engineering involves:



(Extracted from Inayat et al. 2015)

❖ RE4AI



(Extracted from Amershi et al. 2019)

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Challenges in building requirements for AI-based systems

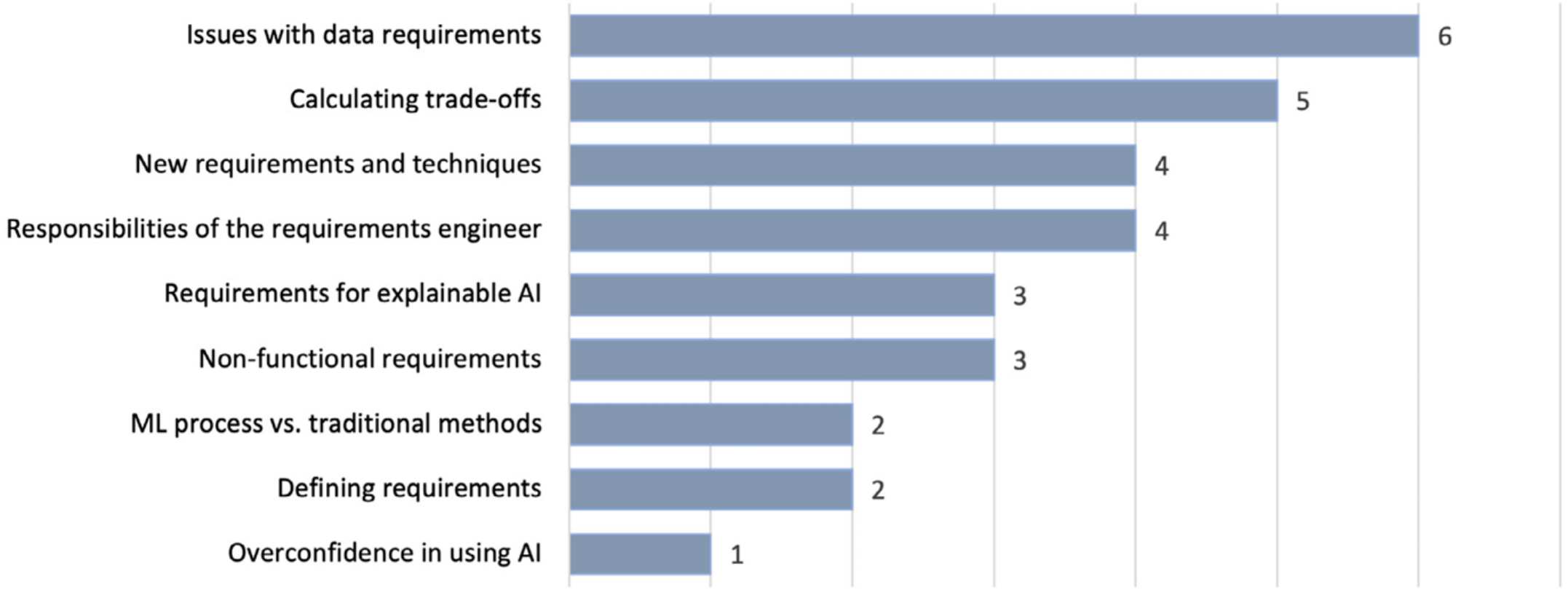

Figure 1: Number of RE4AI issues as appeared in the literature. Source: Ahmad et al. 2023

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Data requirements

- Data-generation expense – Shin et al. (2019)
- Data availability and quality – Weihrauch et al. (2018)
- Training and testing of data – Nakamichi et al. (2020)
- Lack of structure and rules appropriate to train an AI system using the available data – Sandkuhl (2019).

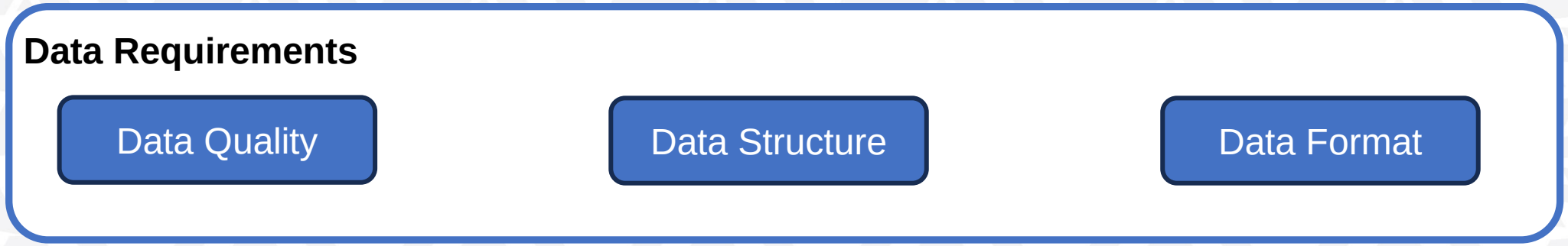

Figure 2: Part of data-related AI requirements to be considered as proposed by Ahmad et al.(2023)

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Calculating Trade-offs

- Confusion in making important choices.
  - Conflicting choices (positive or negative).
  - Cost implications, and impact of letting go of one of the choices.

- For example,
  - Trading privacy for transparency?

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Emergence of new requirements

- **New requirements -**
  - Data, ethics, trust, and transparency.
  - Requires clear specifications for adequate integration into the current practices.

Requirements engineer responsibilities

- Lack of capacity to handle large amounts of data.

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Non-functional requirements (NFR)

- **Traditional SE NFR**
  - Challenges adapting to fit AI-based systems due to its unpredictable nature.
  - Some NFRs might become less important in AI-based systems.
  - For example,
    - ✓ Fairness and transparency are very important in AI-based systems while compatibility and modularity now have little or no importance.

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Machine learning vs Traditional Methods

- **Traditional SE**
  - Has a well-established RE process
  - Outcomes of Traditional SE are mostly predictable
- **AI-based systems**
  - Outcome can be unpredictable
  - Models require dataset training, and testing (Arpteg et al. 2018).

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Requirement definitions

- Vagueness of some attributes
  - Explainability, privacy, ethics, resilience, etc.
- Lack of clarity in defining vague attributes
  - For example, how can we define fairness? How do we explain a term that has multiple meanings to an AI-based system?

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Current Approaches

- RE4AI
  - GORE
  - UML
- SE4AI
  - Need approaches that can be scaled to AI-based systems, specifically in problem formulation.
- Gore-Oriented Requirement Engineering (GORE)
  - Goal modeling and reasoning
    - ✓ Take humans to mars
    - ✓ Maintain speed
  - Lacks semantics for action verbs
  - Direct logical conflicts can be identified
    - ✓ Implicit conflicts are challenging.
  - No explicit representation of design, and its traceability to goals

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Current Approaches

- UML
  - Easy to use
  - Not flexible to model NFR and business rules

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Summary

- We present the challenges of developing requirements based on existing literature.
- We found 9 most challenges as identified by various researchers.
- Current approaches to solving the challenges are also discussed with their limitations.
- Further studies will further use goal-oriented requirement engineering (GORE) and introduce requirement specifications for AI-based systems in addressing most of the identified challenges

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Thank You!!!