Background on Knowledge Representation and Reasoning (KRR)

1 Overview of KRR

Knowledge Representation and Reasoning (KRR) is a subfield of artificial intelligence (AI) that focuses on how knowledge can be represented and reasoned about. This allows machines to interpret, use, and derive conclusions from knowledge, enabling them to simulate human-like understanding and decision-making. KRR bridges the gap between raw data and actionable knowledge by utilizing formal representations and reasoning techniques.

2 Relationship between Data, Information, and Knowledge

KRR is based on understanding the relationship between:

- **Data:** Raw, unprocessed facts without context.

- **Information:** Data that has been given meaning through relationships.

- **Knowledge:** The application of information in meaningful ways that support reasoning and decision-making [1].

The **DIKW pyramid** (Data, Information, Knowledge, Wisdom) illustrates the progression from raw data to wisdom:

- From Data to Information requires context and meaning.

- From Information to Knowledge requires understanding.

- From Knowledge to Wisdom requires experience and judgment [1].

3 Language as a Form of Knowledge Representation

Natural language serves as a form of knowledge representation. Language is a system of symbols (spoken, written, or manual) that conveys meaning and

facilitates communication within a cultural or social group. However, natural language can be ambiguous and complex, presenting challenges for machines to interpret correctly [1].

Understanding language depends on several factors:

- **Syntax:** The structure and arrangement of symbols or words.

- **Semantics:** The meaning derived from the syntax.

- **Context:** The situation or environment in which language is used.

- **Pragmatics:** The intention behind the language usage.

- **Experience:** Prior knowledge and understanding influence interpretation [1].

4 Formal Knowledge Representation

Unlike raw data or natural language, formal knowledge representation structures information in a way that allows machines to interpret and reason about it effectively. Formal representation systems, such as ontologies and knowledge graphs, use logical methods to represent relationships and enable machines to perform reasoning [1].

Formal systems used in KRR include:

- **Mathematical Logic:** Provides a framework for expressing semantics and reasoning.

- **Ontologies:** Define shared vocabularies and relationships between concepts.

- **Knowledge Graphs:** Link data in a structured way to represent knowledge and its relationships [1].

5 The Semantic Web and Linked Data

The **Semantic Web** is an extension of the current web where the meaning (semantics) of data is made explicit through formal structures. The goal is to allow machines to automatically process and reason about the information. Technologies like ontologies and knowledge graphs enable this automation by representing the relationships between concepts [1].

Key concepts include:

- **Linked Data:** A method for publishing structured data on the web so it can be interlinked and used by machines.

- **RDF (Resource Description Framework):** A framework for representing information as triples (subject-predicate-object).

- **SPARQL:** A query language used to retrieve and manipulate RDF data [1].

6 From Traditional Data Structures to Knowledge Representation

Traditional data structures, such as relational databases, focus on storing and retrieving data. In contrast, **knowledge representation** focuses on capturing the meaning and relationships between data points, enabling machines to perform reasoning and derive new knowledge through logical inferences [1].

7 Conclusion

KRR plays a central role in enabling AI systems to reason and make decisions based on structured knowledge. By employing formal methods like knowledge graphs and ontologies, KRR systems help build intelligent agents that can automate decision-making, drive semantic search engines, and power natural language processing applications. KRR is essential to advancing the capabilities of AI systems to understand and interact with the world.

References

[1] Dr. Amna Basharat & Ms. Amna Binte Kamran, *Knowledge Representation & Reasoning, Fall 2023*, Course Introduction - Week 2, KRR Fall 2023, September 2023.