Intelligent Information Systems

Prof. M. Muraszkiewicz, *mrm@ii.pw.edu.pl*

Lecture Notes: Module 2

HUMAN CAPITAL
HUMAN – BEST INVESTMENT!

EUROPEAN UNION
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Knowledge Representation

Module 2

Prologue

Aristotle Speaks

"All men by nature desire to know."

“Experience is knowledge of individuals.”

Aristotle "Metaphysics"

Immanuel Kant Speaks

"Science is organized knowledge. Wisdom is organized life”

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Knowledge – What is?

Question 1

Do we discover or invent knowledge?

Question 2

Can computers be a useful tool for acquiring and retrieving knowledge, supporting reasoning and thinking?

What's Knowledge?

There is no widely accepted definition of knowledge.

Knowledge is related to:

- **objects**
- **facts**
- **events**
- **procedures**
- **itself (meta-knowledge)**

What's Knowledge, again?

-- Colloquially, knowledge is a set of experiences and/or convictions.

-- In philosophy, knowledge is a set of consistent and justified convictions.

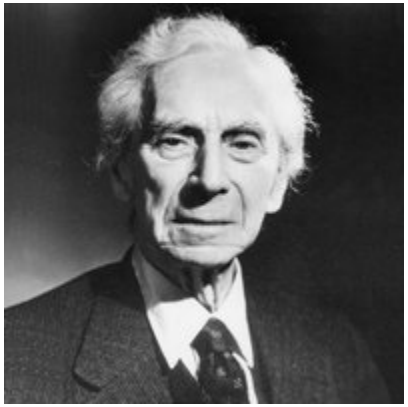
-- In science, knowledge is a set of empirically or logically/mathematically consistent and justified assertions that can be subject to falsification or critique (K. Popper).

What's Knowledge, again?

If one can classify,
then one knows.

&

Vice versa



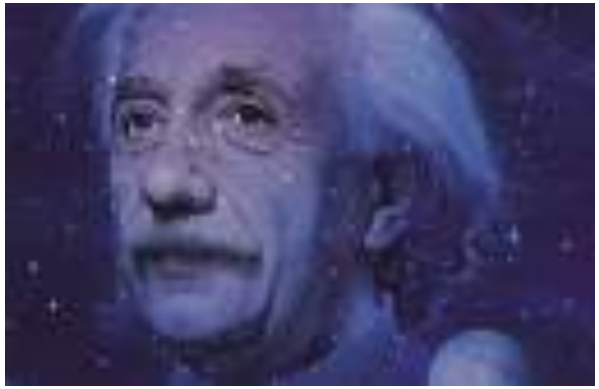
Z. Pawlak

B. Russel

What's Knowledge, again?

"Knowledge is experience"

(***A. Einstein***)



What's Knowledge, again?

Knowledge is a necessary condition to undertake effective and efficient actions.

(***mantra of the corporate world, ... and some other entities ☺)***

Knowledge in Organizations

Data, information, procedures regarding products, services, markets, technologies and business processes, which the organization possesses (or should have) to create added value.

- own and collaborating experts & consultants
- technologies (*know-how*)
- processes
- patents
- regulations
- organizational solutions
- relations with customers
- ...

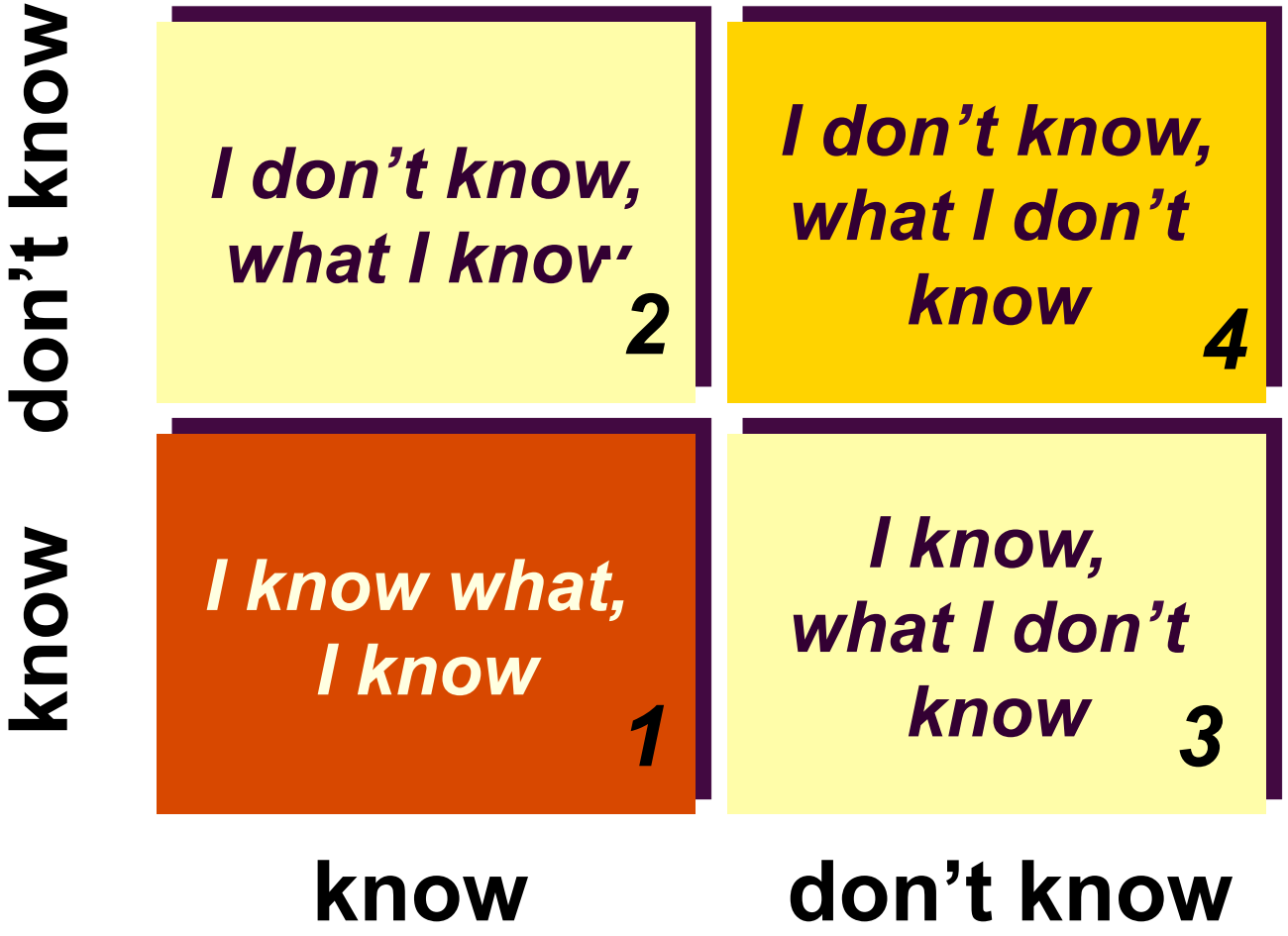
- databases
- data warehouses
- intranet resources
- computer programs
- e- and conventional archives, including email archives
- lists, inventories
- ...

A Tricky Question

Can knowledge be false?

The False Mirror,
Rene Magritte

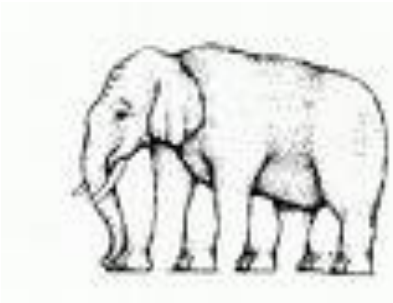
Square of Meta-knowledge



Knowledge Representation (KR)

Representation Matters

text	code
J	0100 1010
O	0100 1111
H	0100 1000
N	0100 1110

on paper	in computer
	

Representation Matters

MCCCXXVI * XCVII = ? ⟺ 1326 * 97 = 128,622

"At PARC we had a slogan: Point of view is worth 80 IQ points.
It was based on a few things from the past like how smart you had to be in Roman times to multiply two numbers together; only geniuses did it.
We haven't gotten any smarter, we've just changed our representation system. We think better generally by inventing better representations; that's something that we as computer scientists recognize as one of the main things that we try to do."

|Alan Kay

KR – What for ?

-- To register knowledge:

(i) documentation, (ii) communications.

-- To readily manipulate knowledge for:

(i) recognition, (ii) learning, (iii) …

-- Study human's intelligence.

Note

The scope and directions of works on KR (Knowledge Representation) are determined by the intended application of the KR and, to some extent, by the way the knowledge will be acquired.

Hence, there is no definition, accepted by all interested parties of *Knowledge representation*.

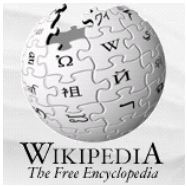
Classic Definition of KR

“Knowledge representation is a description of the world and/or its states.”

R. Brachman, H. Levesque, 1985

KR in Wikipedia

"The term Knowledge Representation is most commonly used to refer to representations intended for processing by modern computers, and particularly for representations consisting of explicit objects, and of assertions or claims about them. Representing knowledge in such explicit form enables computers to draw conclusions from knowledge already stored"



http://en.wikipedia.org/wiki/Knowledge_representation

KR by J. Sowa

"Knowledge representation is a multidisciplinary subject that applies theories and techniques from three other fields:

- Logic provides the formal structure and rules of inference.

- Ontology defines the kinds of things that exist in the application domain.

- Computation supports the applications that distinguish knowledge representation from pure philosophy."

John F. Sowa, „Knowledge Representation: Logical, Philosophical, and Computational Foundations", Brooks Cole Publishing Co., Pacific Grove, 2000

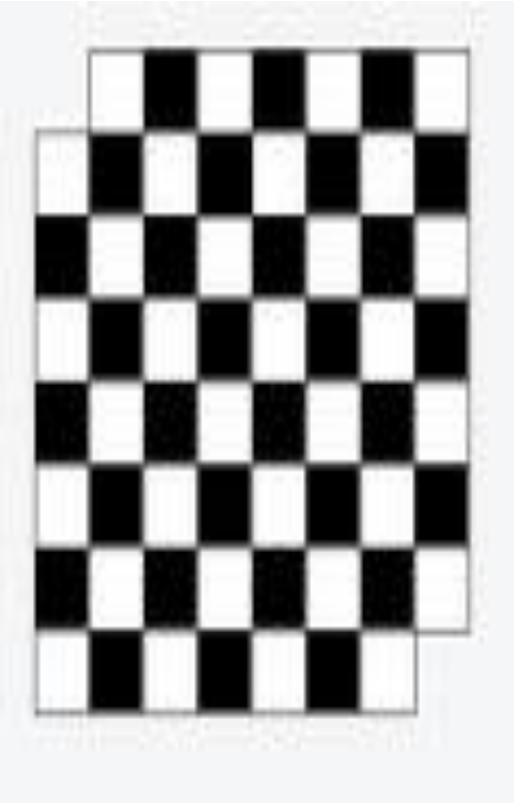
Five Roles of KR

- A knowledge representation (KR) is most fundamentally a surrogate, a substitute for the thing itself, used to enable an entity to determine consequences by thinking rather than acting, i.e., by reasoning about the world rather than taking action in it.
- It is a set of ontological commitments, i.e., an answer to the question: In what terms should I think about the world?
- It is a fragmentary theory of intelligent reasoning, expressed in terms of three components: (i) the representation's fundamental conception of intelligent reasoning; (ii) the set of inferences the representation sanctions; and (iii) the set of inferences it recommends.
- It is a medium for pragmatically efficient computation, i.e., the computational environment in which thinking is accomplished. One contribution to this pragmatic efficiency is supplied by the guidance a representation provides for organizing information so as to facilitate making the recommended inferences.
- It is a medium of human expression, i.e., a language in which we say things about the world.

R. Davis, H. Shrobe, P. Szolovits, MIT AI Lab and Symbolics, Inc.
http://groups.csail.mit.edu/medg/ftp/psz/k-rep.html

Our Definition of KR

KR is a methodology of presenting the knowledge about the world along with the procedures for processing this representation, especially by means of reasoning (inference)



Formal Definition of KR Method

KR =

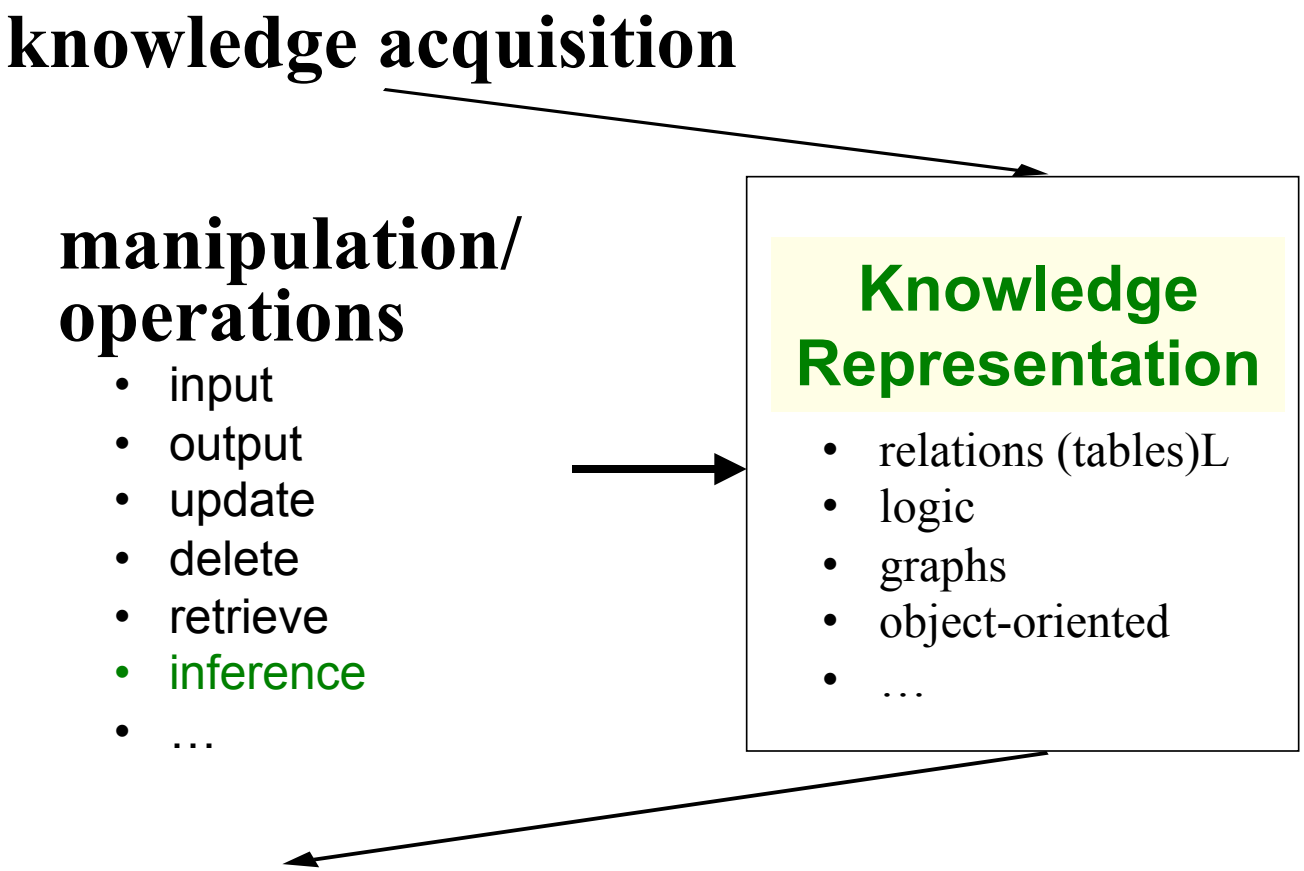
<

KR_Description_Language,

KR_Processing_Mechanism
including Inference_Mechanism

>

KR Processes



Problems and Properties of KR

- subject and scope (“what can be represented?"),
- trustfulness / timeliness / completeness,
- granularity / accuracy,
- what is the trade off between accuracy and processing cost?

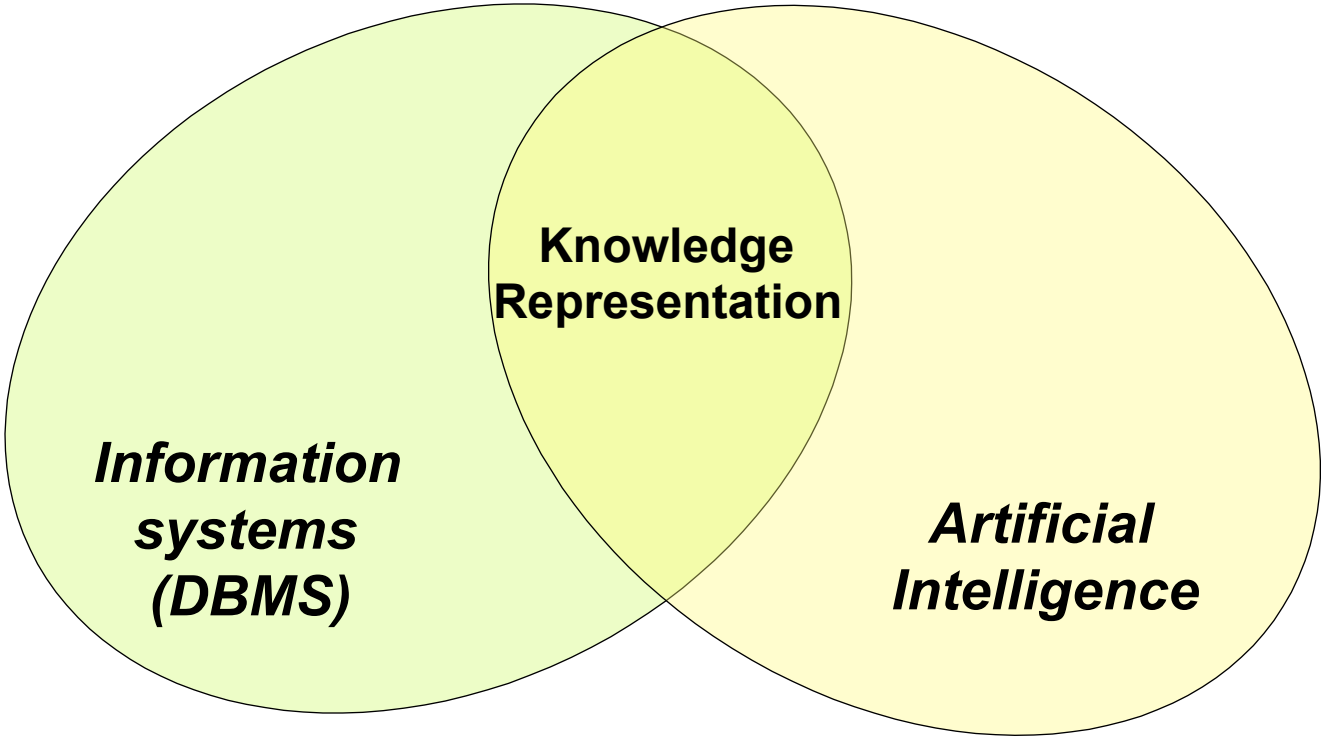
Problems and Properties of KR

- modularity / context (amenability to add, delete, modify components),
- legibility for humans,
- representation of incomplete knowledge, convictions, common sense,
- representation of time and processes,
- explicit – implicit knowledge ("embedded", e.g. in a program),

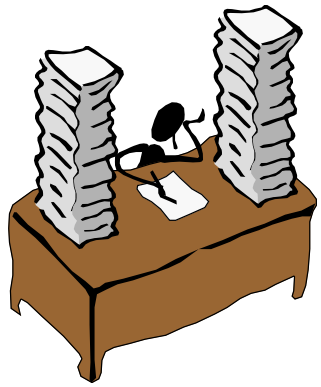
Problems and Properties of KR

- non-deductive reasoning,
- non-monotonic reasoning,
- reliability and efficiency and effectiveness of reasoning,
- representation of meta-knowledge,
- procedural, non-procedural representation,
- .... *other*

IS, AI, KR - Relationship



Recommended Readings:



- Ronald Brachman, Hectore Levesque (editors): „Readings in Knowledge Representation”, Morgan Kaufmann, 1985.
- Ronald Brachman, Hectore Levesque, „Knowledge Representation and Reasoning ”, Morgan Kaufmann, 2004.
- R. Davis, H. Shrobe, and P. Szolovits, „What is a Knowledge Representation?”, AI Magazine, 14(1):17-33, 1993
- John F. Sowa, „Knowledge Representation: Logical, Philosophical, and Computational Foundations”, Brooks Cole Publishing Co., Pacific Grove, 2000
- http://en.wikipedia.org/wiki/Knowledge_representation

Methods of KR

KR Methods Origins

Analytical, symbolic

Invented by researchers

(inspired by logics and math – J. von Neumann).

„Naturalistic”

Based on solutions worked out by “mother nature” through evolution

(inspired by psychology, neurology, biology, evolution – K. Darwin, ...).

KR Methods

- Natural language
- Methods used for databases, e.g. UML
- Standard and non-standard logics
- Production rules
- Semantic networks
- Decision trees
- Concept graphs
- Ontologies
- Frames, scripts
- Pawlak's rough sets
- XML (?)
- Neural nets
- Genetic algorithms
- ...

Our Propositions -- Wrap up

For the sake of the class discussions three vital assumptions have been adopted:

- **A broad concept of intelligence is reduced to the mechanism of reasoning.**
- **A discussion on intelligent information systems is confined (narrowed down) to the review and analysis of knowledge representation.**
- **KR = <*Language*, *Operations including Inference_Mechanism*>**

Epilogue

Knowledge is Heavy!

“There was so much handwriting on the wall that even the wall fell down”

Christopher Morley

Thank you!

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