Tutorial:

On the Selection of a Suitable AI Technique for Solving a Given Problem

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Overview (1st hour)

• Introduction & overview	*mins: 10*
• What type of problems are suitable for AI solutions?	*5*
• Finding the suitable AI technique for a given problem	*5*
• The intelligence density framework (Dhar & Stein '97)	*25*
• Brief review of selected AI techniques	*15*

- Neural networks
- Genetic algorithms
- Rule-based systems
- Fuzzy logic

Overview (2nd hour)

- Intelligence density profiles of the selected techniques *15*
- An objective AI technique selection procedure *5*
- The selection procedure in action: *30*
  - Credit card issuance
  - Determination of the optimal drug dosage
  - Prediction of the preference cards of the cabin crew of an airline
  - ???
- Conclusions & wrap-up *10*

Problems Suitable for AI Solutions

if the nature of computations required in a task is not well understood

or there are too many exceptions to the rules

or known algorithms are too complex or inefficient

then AI has the potential of offering an acceptable solution

Selection of an Appropriate AI Technique

- A given problem can always be solved in several ways

- Even if 2 techniques produce solutions of a similar quality, matching the right technique to a problem can save on time & resources

- Characteristics of an optimal technique:
  - The solution contains all of the required information
  - The solution meets all other necessary criteria
  - The solution uses all of the available (useful) knowledge
  - ???

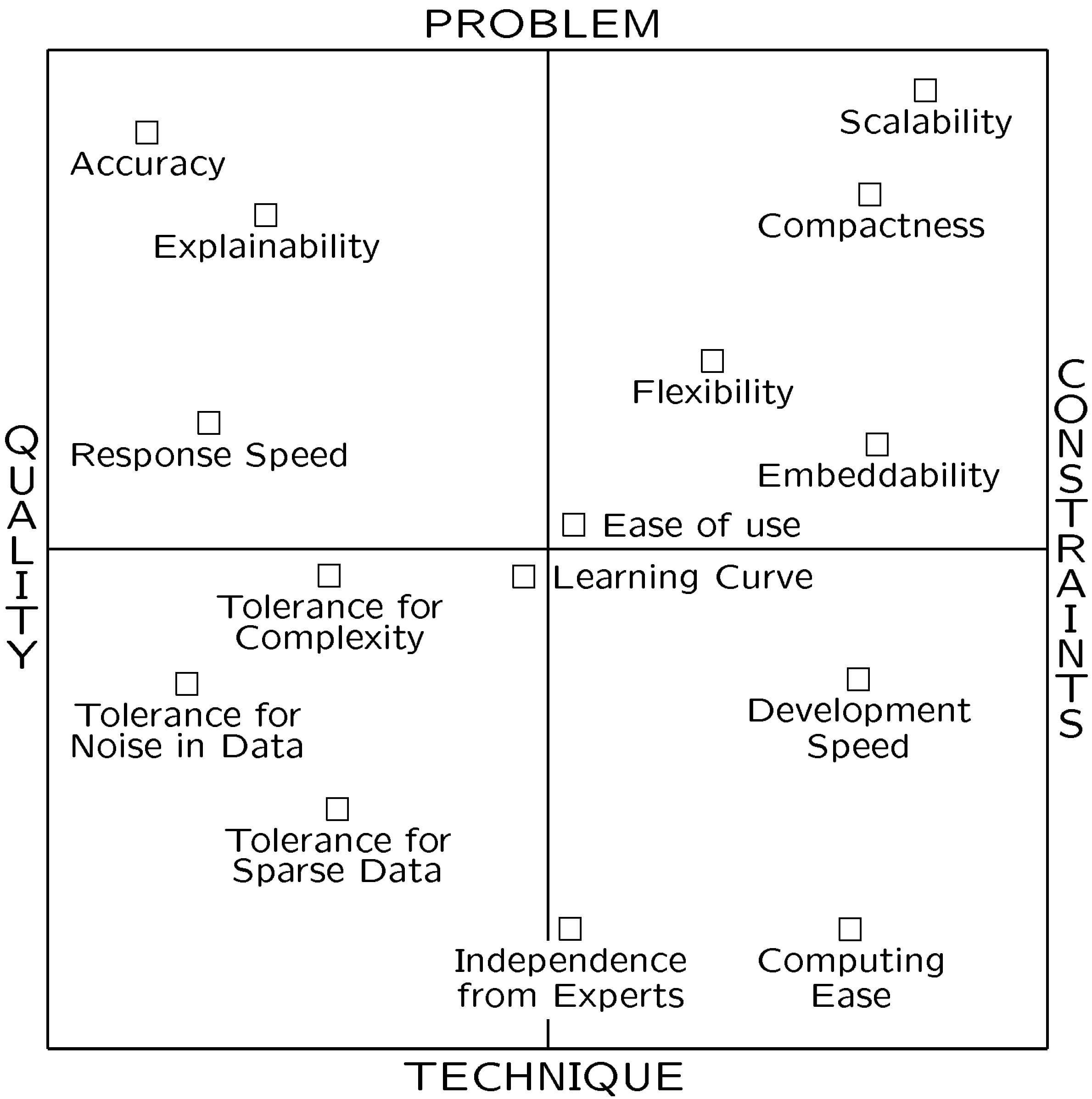
The Intelligence Density Framework

- *IDF:* A vocabulary, proposed by Dhar & Stein (1997), for describing the objectives and constraints of a problem or technique

- Elements of the vocabulary act like a 'committee of critics', each trying to influence the outcome of the project in a selfish manner

- A successful project is executed if:
  - The selected technique satisfies most of the critics in the problem's 'committee of critics' to a reasonable degree
  - It does so without overly upsetting the remaining critics

The Fifteen 'Critics' of the IDF



Why IDF?

IDF is helpful because it encourages the designer to consider *early* in the life-cycle the issues that she will face during the . . .

- Development phase
- Deployment phase
- Post-deployment phase

Review of Selected AI Techniques

- Neural networks (NN)
- Genetic algorithms (GA)
- Rule-based systems (RBS)
- Fuzzy logic (FL)

Neural Networks

- Original inspiration was the human brain, emphasis now on usefulness as a computational tool

- Many useful NN paradigms, but scope of today's discussion limited to the feedforward net, the most popular paradigm:
  - It is a layered structure consisting of a number of homogeneous and simple (but nonlinear) processing elements
  - All processing is local to a processing element and is asynchronous

- During training the NN is forced to adjust its parameters so that its response to I/P data becomes closer to the desired response

Genetic Algorithms

- Based on Darwin's evolutionary principle of 'survival of the fittest'
- GAs require the ability to recognize a good solution, but not how to get to that solution
- The algorithm:
  - An initial set of random solutions is ranked in terms of ability to solve the problem at hand
  - The best solutions are then cross-bred and mutated to form a new set
  - The ranking and formation of new solutions is continued until a good enough solution is found or . . .

Rule-based Systems

- Based on the principles of the logical reasoning ability of humans
- Components of an RBS:
  - Rule-base
  - Working memory
  - Rule interpreter
- The design process:
  - An RBS engineer interviews the expert to acquire the comprehensive set of heuristics that covers the situations that may occur in a given domain
  - This set is then encoded in the form of IF–THEN structures to form the required RBS

Fuzzy Logic

- Based on the principles of the approximate reasoning faculty that humans use when faced with linguistic ambiguity
- The inputs and outputs of a fuzzy system are precise, only the *reasoning* is approximate
- Parts of the knowledge-base of a fuzzy system:
  - Fuzzy rules
  - Fuzzy sets
- The output of a fuzzy system is computed by using:
  - The MIN–MAX technique for combining fuzzy rules
  - The centroid method for defuzzification

Intelligence Density Profile of NNs

DIMENSION	VALUE	BUT...
Accuracy	■■■■■	
Explainability	■	
Response speed	■■■■■	
Scalability	■■■	
Compactness	■■■■■	
Flexibility	■■■■■	
Embeddability	■■■■■	
Ease of use	■■■	
Learning curve	■■■■■	
Tolerance for complexity	■■■■■	
Tolerance for noise in data	■■■■	
Tolerance for sparse data	■	
Independence from experts	■■■■■	
Development speed	■■■	
Computing ease	■■	

Intelligence Density Profile of GAs

DIMENSION	VALUE	BUT...
Accuracy	■■■	
Explainability	■■	
Response speed	■■■■	
Scalability	■■■	
Compactness	■■■	
Flexibility	■■■■■	
Embeddability	■■■■■	
Ease of use	■■■	
Learning curve	■■■■■	
Tolerance for complexity	■■■■■	
Tolerance for noise in data	■■■	
Tolerance for sparse data	■■■	
Independence from experts	■■■■■	
Development speed	■■■■	
Computing ease	■■	

Intelligence Density Profile of RBSes

DIMENSION	VALUE	BUT...
Accuracy	■■■	
Explainability	■■■■■	
Response speed	■■	
Scalability	■■■	
Compactness	■	
Flexibility	■■■	
Embeddability	■	
Ease of use	■■■	
Learning curve	■■	
Tolerance for complexity	■	
Tolerance for noise in data	N.A.	
Tolerance for sparse data	N.A.	
Independence from experts	■	
Development speed	■■■■	
Computing ease	■■■	

Intelligence Density Profile of FL

DIMENSION	VALUE	BUT...
Accuracy	■■■■■	
Explainability	■■■	
Response speed	■■■■■	
Scalability	■■	
Compactness	■■■■■	
Flexibility	■■■■■	
Embeddability	■■■	
Ease of use	■■■	
Learning curve	■■■	
Tolerance for complexity	■■■	
Tolerance for noise in data	N.A.	
Tolerance for sparse data	N.A.	
Independence from experts	■	
Development speed	■■■	
Computing ease	■■■■■	

AI Technique Selection Procedure

1. Determine the IDP of the problem at hand
2. Compare that IDP with those of the available AI techniques
3. Use the AI technique having the most well matched profile

The Selection Procedure in *Action*

1. Credit card issuance

2. Determination of the optimal drug dosage

3. Prediction of the preference cards of the cabin crew of an airline

4. ???

Credit Card Issuance

Challenge. Increase the acceptance rate of card applicants who will turn out to be good credit risks

Inputs. Applicant's personal and financial profiles

Output. Estimated yearly loss if application is accepted

Expert knowledge. Some rules of thumb are available

Data. Profiles & loss data available for 1M+ applicants

Credit Card Issuance: IDP

DIMENSION	GOAL	NN	GA	RBS	FL
Accuracy	□□□□□	■■■■■	■■■	■■■	■■■■■
Explainability	□□□□□	■	■■	■■■■■	■■■
Response speed	□□□□□	■■■■■	■■■■	■■	■■■■■
Scalability	□□□□□	■■■	■■■	■■■	■■
Compactness	□□□□□	■■■■■	■■■	■	■■■■■
Flexibility	□□□□□	■■■■■	■■■■■	■■■	■■■■■
Embeddability	□□□□□	■■■■■	■■■■■	■	■■■
Ease of use	□□□□□	■■■	■■■	■■■	■■■
Learning curve	□□□□□	■■■■■	■■■■■	■■	■■■
Tolerance for complexity	□□□□□	■■■■■	■■■■■	■	■■■
Tolerance for noise in data	□□□□□	■■■■	■■■	N.A.	N.A.
Tolerance for sparse data	□□□□□	■	■■■	N.A.	N.A.
Independence from experts	□□□□□	■■■■■	■■■■■	■	■
Development speed	□□□□□	■■■	■■■■	■■■■	■■■
Computing ease	□□□□□	■■	■■	■■■	■■■■■
Best match					

Determination of the Optimal Drug Dosage

Challenge. Warn the physician if she prescribes a dosage which is either too high or too low

Inputs. Patient's medical record. Pharmaceutical drug dosage instructions

Output. Warning along with reasons for the warning

Data. Medical records of thousands of patients. Drug dosage instructions on dozens of medicines

Determination of the Optimal Dosage: IDP

DIMENSION	GOAL	NN	GA	RBS	FL
Accuracy	□□□□□	■■■■■	■■■	■■■	■■■■■
Explainability	□□□□□	■	■■	■■■■■	■■■
Response speed	□□□□□	■■■■■	■■■■	■■	■■■■■
Scalability	□□□□□	■■■	■■■	■■■	■■
Compactness	□□□□□	■■■■■	■■■	■	■■■■■
Flexibility	□□□□□	■■■■■	■■■■■	■■■	■■■■■
Embeddability	□□□□□	■■■■■	■■■■■	■	■■■
Ease of use	□□□□□	■■■	■■■	■■■	■■■
Learning curve	□□□□□	■■■■■	■■■■■	■■	■■■
Tolerance for complexity	□□□□□	■■■■■	■■■■■	■	■■■
Tolerance for noise in data	□□□□□	■■■■	■■■	N.A.	N.A.
Tolerance for sparse data	□□□□□	■	■■■	N.A.	N.A.
Independence from experts	□□□□□	■■■■■	■■■■■	■	■
Development speed	□□□□□	■■■	■■■■	■■■■	■■■
Computing ease	□□□□□	■■	■■	■■■	■■■■■
Best match					

Prediction of Airline Cabin Crew's Preferences

Challenge. Predict the future base/status preferences of the cabin crew of an airline. The predicted preferences will be used by the airline for forecasting its staffing and training requirements

Inputs. Crew's personal profiles. Preference history. Other data

Output. Predicted preference card for todays date plus one year

Expert knowledge. Some rules of thumb are available

Data. Available for the last four years for 8000 crew members

Prediction of Cabin Crew's Preferences: IDP

DIMENSION	GOAL	NN	GA	RBS	FL
Accuracy	□□□□□	■■■■■	■■■	■■■	■■■■■
Explainability	□□□□□	■	■■	■■■■■	■■■
Response speed	□□□□□	■■■■■	■■■■	■■	■■■■■
Scalability	□□□□□	■■■	■■■	■■■	■■
Compactness	□□□□□	■■■■■	■■■	■	■■■■■
Flexibility	□□□□□	■■■■■	■■■■■	■■■	■■■■■
Embeddability	□□□□□	■■■■■	■■■■■	■	■■■
Ease of use	□□□□□	■■■	■■■	■■■	■■■
Learning curve	□□□□□	■■■■■	■■■■■	■■	■■■
Tolerance for complexity	□□□□□	■■■■■	■■■■■	■	■■■
Tolerance for noise in data	□□□□□	■■■■	■■■	N.A.	N.A.
Tolerance for sparse data	□□□□□	■	■■■	N.A.	N.A.
Independence from experts	□□□□□	■■■■■	■■■■■	■	■
Development speed	□□□□□	■■■	■■■■	■■■■	■■■
Computing ease	□□□□□	■■	■■	■■■	■■■■■
Best match					

Example [ ]

Challenge.

Inputs.

Output.

Expert knowledge.

Data.

Example [ ]: IDP

DIMENSION	GOAL	NN	GA	RBS	FL
Accuracy	□□□□□	■■■■■	■■■	■■■	■■■■■
Explainability	□□□□□	■	■■	■■■■■	■■■
Response speed	□□□□□	■■■■■	■■■■	■■	■■■■■
Scalability	□□□□□	■■■	■■■	■■■	■■
Compactness	□□□□□	■■■■■	■■■	■	■■■■■
Flexibility	□□□□□	■■■■■	■■■■■	■■■	■■■■■
Embeddability	□□□□□	■■■■■	■■■■■	■	■■■
Ease of use	□□□□□	■■■	■■■	■■■	■■■
Learning curve	□□□□□	■■■■■	■■■■■	■■	■■■
Tolerance for complexity	□□□□□	■■■■■	■■■■■	■	■■■
Tolerance for noise in data	□□□□□	■■■■	■■■	N.A.	N.A.
Tolerance for sparse data	□□□□□	■	■■■	N.A.	N.A.
Independence from experts	□□□□□	■■■■■	■■■■■	■	■
Development speed	□□□□□	■■■	■■■■	■■■■	■■■
Computing ease	□□□□□	■■	■■	■■■	■■■■■
Best match					

Conclusions

1. Selection of the right AI technique requires intimate knowledge about the problem as well as the techniques under consideration

2. The process of selection can be made easier by formulating the problem in terms of its IDP

3. Real problems may require a combination of techniques (AI and/or non-AI) for an optimal solution

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