Artificial Intelligence: Pattern Recognition

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Course: CSE 352 Artificial Intelligence

Work Cited

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Brief Overview:
What is a Pattern?
Why do we use Patterns?
What is Pattern Recognition?
How do we use Pattern Recognition?
What are some approaches to pattern recognition?
What are some applications of pattern recognition?

"A pattern is the opposite of a chaos; it is an entity vaguely defined, that could be given a name."
-Watanabe

What is Pattern Recognition?

Pattern Recognition:

Pattern recognition is one of the four cornerstones of Computer Science. It involves finding the similarities or patterns among small, decomposed problems that can help us solve more complex problems more efficiently.

Source: http://www.bbc.co.uk/education/guides/zxxbgk7/revision/3

Key Components

- Data Acquisition and Collection
- Feature extraction and Representation
- Similarity Detection and Pattern Classifier Design
- Performance Evaluation

These make up the process for "making sense"of known and unknown data and avoid misclassification error.

Four Cornerstones of Computational Thinking

- Decompose the problem.
- Abstract the problem.
- Develop algorithms to solve the problem.
- Recognize patterns in the problem.
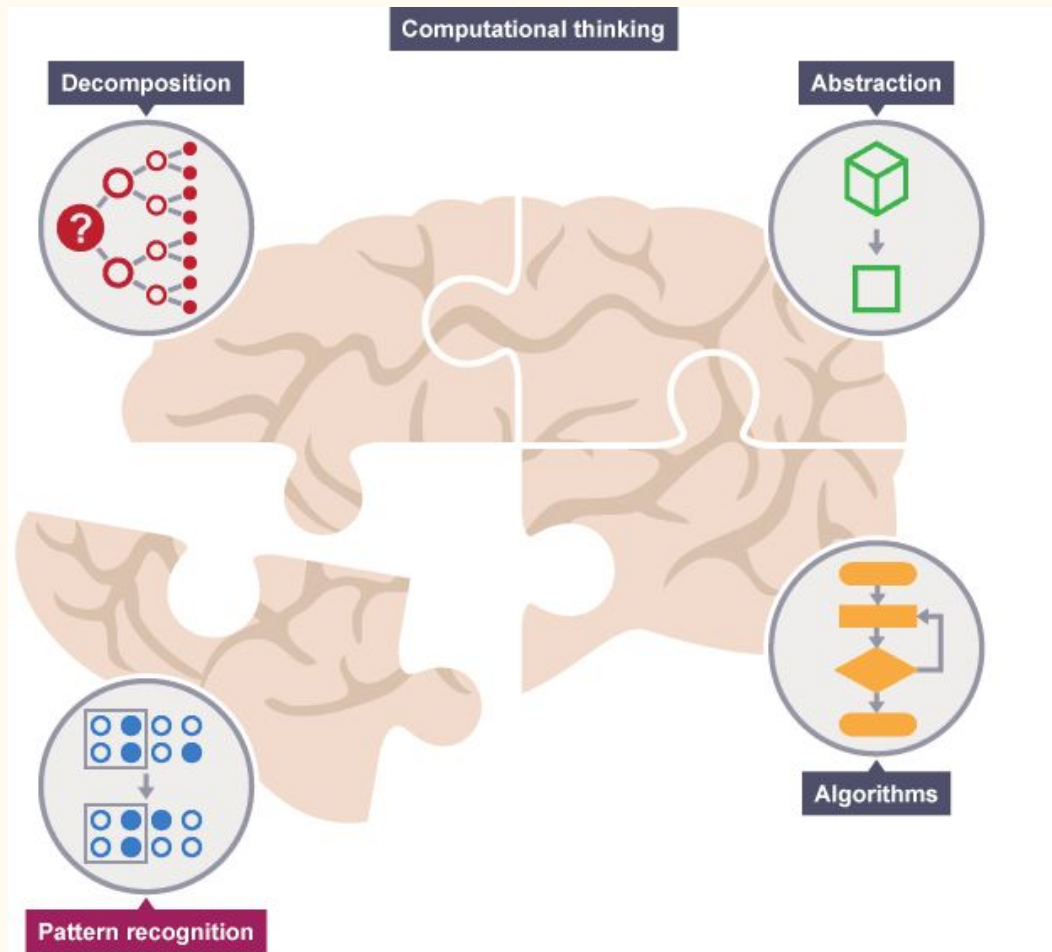
ImageSource:

Why do we need to look for patterns?

- Finding patterns are extremely important because patterns make our tasks simpler. Problems are easier to solve when they share patterns, because we can use the same problem-solving solution wherever the pattern exists.
- The more patterns we can find, the easier and quicker our overall task of problem solving will be.
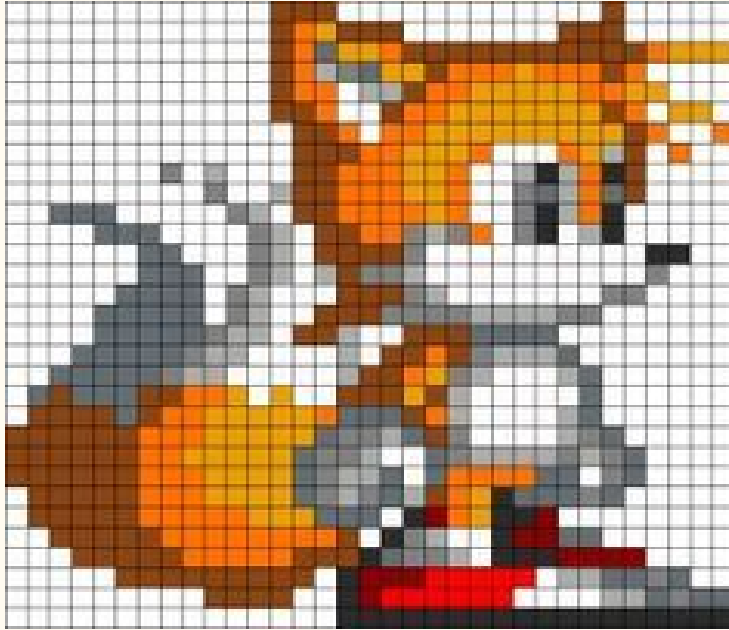
Examples of Patterns

Image Sources: https://www.pinterest.com/pin/75576099970297394/
http://www.smithsonianmag.com/science-nature/science-behind-natures-patterns-180959033/

Classifications of Pattern Recognition

Pattern recognition uses key features to classify input data into objects or classes. There are two methods of classification: Supervised and unsupervised classification. Using these classifications, pattern recognition applications include :

- Computer Vision
- Optical Character Recognition (Handwritten or Digital Text Documents)
- Radar Processing
- Speech Recognition

Supervised Classification

Supervised pattern recognition creates classifiers using supervised learning(A type of machine language that uses known data sets to create predictions) algorithms to create classifiers from various object classes. Classifiers that are freshly created then accept input data and create new objects as well as class labels. These techniques are used in computer vision for many things including face detection/recognition, object detection, and optical recognition.

Image Source:
http://www.electronicbeats.net/post_category/pattern-recognition-columns-post-features/
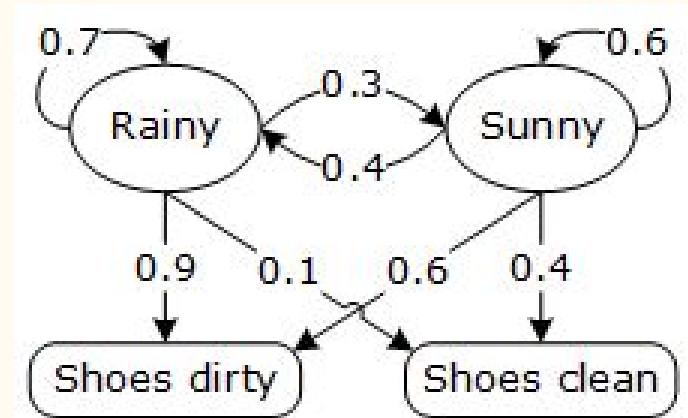
Unsupervised Classification

Unsupervised classification finds hidden features in unlabeled data using clustering or data segmentation techniques. Other techniques include: Gaussian Mixture Models, Hidden Markov Model, and K- clustering.

The Gaussian mixture model for example, allows us to detect moving objects. This is done by classifying the captured objects and background pixels with different colors.

Gaussin below:Image Source: http://www.mathworks.com/discovery/pattern-recognition.html?requestedDomain=www.mathworks.com

Markow right: Image Source: http://recognize-speech.com/images/robert/hmm_intro/example_hmm.png

How to find a Pattern?

To find patterns in problems we look for things that are the same (or very similar) in each problem. It may turn out that no common characteristics exist among problems, but we should still look.

Patterns exist among different problems and within individual problems. So we need to look for both.

In the case of baking a cake now matter what the cake some of the steps are very similar if not the same. Once we know how to identify each ingredient and its amount, we can apply that pattern to all ingredients. Again, all that changes is the specifics.
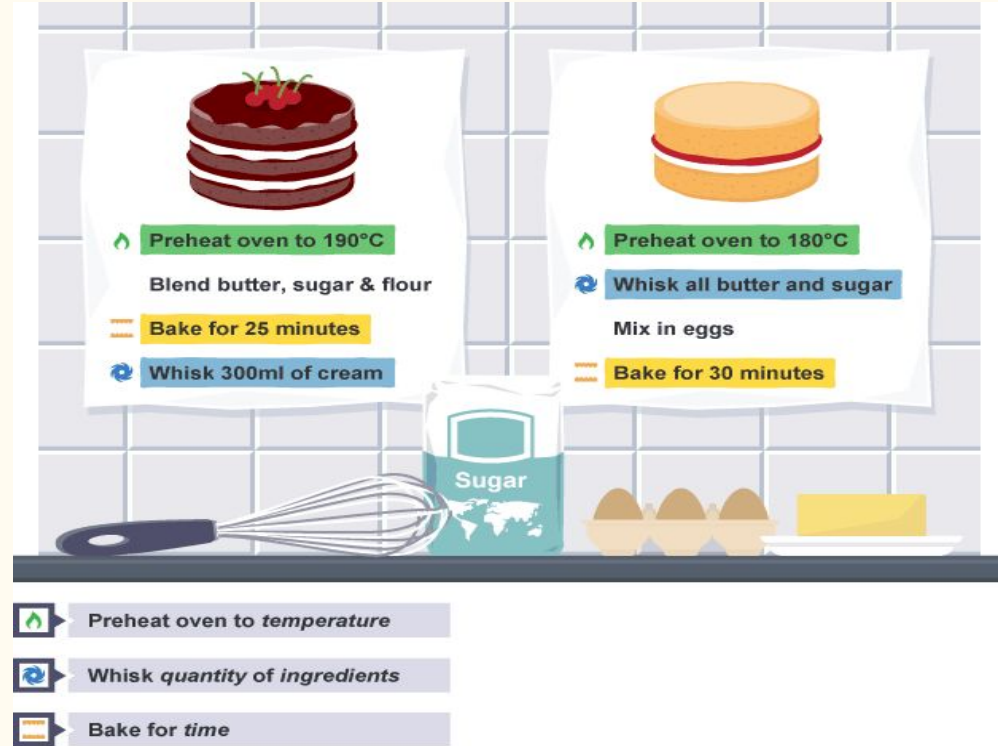

Image Source:
http://www.bbc.co.uk/education/guides/zxxbgk7/revision/3

Problem Formulation

Input object → Measurements Preprocessing → Features → Classification → Class Label

Basic ingredients:

- Measurement space (e.g., image intensity, pressure)
- Features (e.g., corners, spectral energy)
- Type of Classifier - soft and hard
- Decision boundary
- Training sample
- Probability of error

# Once a Potential Pattern is found...

Pattern Recognition Phases

• Preprocessor

– Use a segmentation operation to isolate potential matches from one another

• Information from a match is sent to a feature extractor whose purpose is to reduce the data by measuring certain features

• The features are passed to a classifier

- Selects a possible feature for discrimination
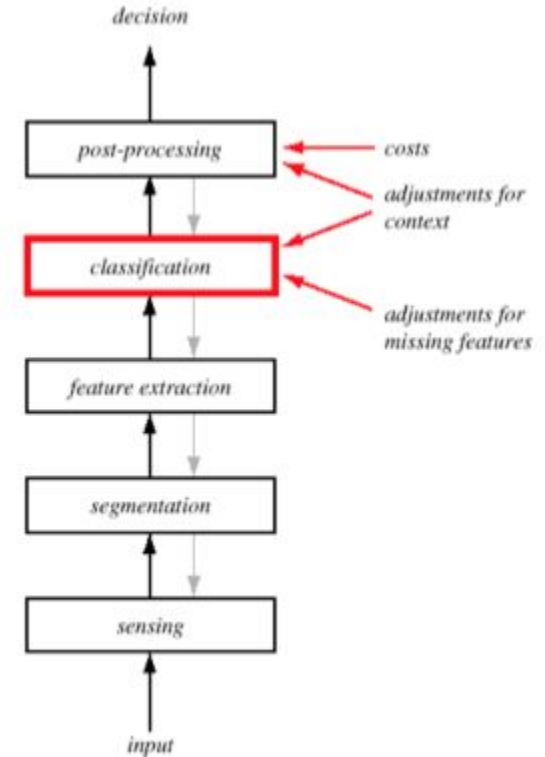
Design Cycle

1. Feature selection and extraction

    -What are good discriminative features?

2. Modeling and learning
3. Dimension reduction, model complexity
4. Decisions and risks
5. Error analysis and validation.
6. Performance bounds and capacity.
7. Algorithms
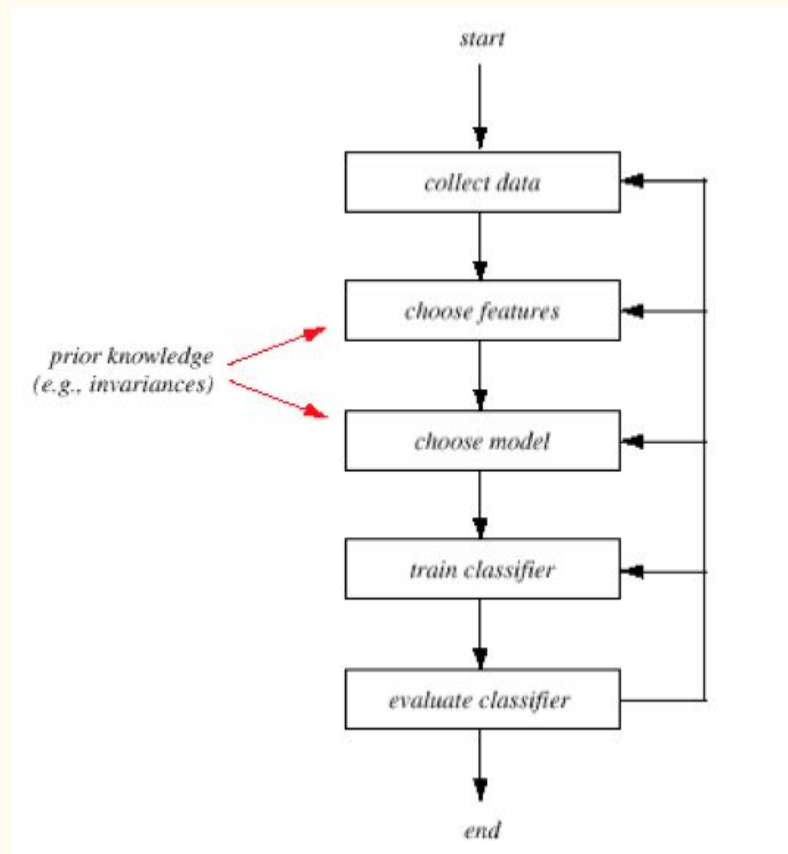
# Approaches/Methods to Pattern Recognition

Approaches

Pattern Recognition is broken down in the following approaches

- **Statistical PR** - Pattern classes are based on statistical modeling of data. The model is then used with probability and decision theory to create algorithms ("A Statistical Learning/Pattern Recognition Glossary", Thomas Minka")

- **Neural Recognition (Neural Network)** - Computer classifiers modeled loosely after the human brain. The goal of this approach is to simulate artificial neural systems by the "learning rule" to recognize input patterns. ("A Basic Introduction To Neural Networks")

- **Syntactic PR** -(structural pattern recognition) is a form of recognition, objects being used (or created) to represent interconnectivity between attributes. ("Role of Pattern Recognition in Computer Games", Timo Kaukoranta, Jouni Smed)

Why are patterns important for AI?

Medical Applications
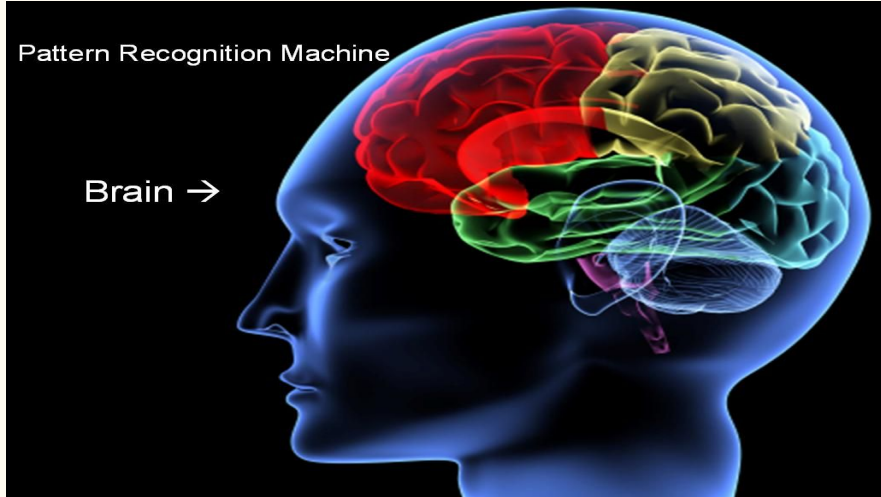
We can get a better understanding of the activity that goes on in the human body by classifying data we know, and do not know. A computer can do in a more efficient amount of time.

Entertainment Applications

For games, a challenging AI is key. Developers must create an AI that can gather information and deduce relevant patterns in order to create quick decision making environments and more human like AI. This requires various methods such as formal language, neural networks, genetic algorithms, and clustering techniques.

Financial Applications

Trading algorithms which identify up trends on selected stock. This is accomplished by applying intelligent computation techniques to trading rules that are based on the recognition of an upward pattern. Results are promising and it is shown that this application easily beats a passive approach, like the Buy&Hold.

VPRT (VistaPrint Ltd) 01/28/2011

Image Source:
http://www.nebadawn.com/pattern-recognition/cup-and-handle-day-trading-with-yahoo-finance-data.htm

More Examples of Pattern Recognition

- **Optical Characters**

  - Handwritten: User input for mobile phones and other devices…

  - Printed: Digitization of text documents.

- **Biometrics**

  - Fingerprints, Speech, Face….

- **Diagnostic Systems**

  - Medical: X-Ray, MRI, EKG…

  - Machine: Diagnostics, Detection of foreign materials,….

- **Military**

  - Automated Target Recognition

  - Image segmentation and analysis

Image Sources:
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