Introduction to AI

José Manuel Rey

June 16th, 2020

A comprehensive overview of the developments in AI both from a conceptual point of view and from its degree of applicability to certain business problems, with a basic explanation of some of the mathematical and technical foundations of its operation and the tools and platforms for its deployment.

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INDEX – Webinar June 16th 2020, 10:00am [1h]

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Revisiting some concepts
Crash-course on Information Theory

- Brute Force / Heuristics / Moonshot
- Searching versus Learning (and greediness)
- What is an Algorithm? Programming Language paradigms
- What is Design?
- Syntax / Semantics / Epistemology

José Manuel Rey, 2019
Algorithms and Language Paradigms (for laymen)

Procedural
If (x=green) and (y=round) then location=A

Functional
apple(x,y):(x=green) and (y=round);
move(z):if z=true assert(location,A);
move(apple(x,y))

Numerical
N1(z1,z2)→0.9
N2(v1)→0.8
N2(N1(0.8,0.3))→0.7

José Manuel Rey, 2019
Design Cycle

- A Code
- Message

Variation Function

Replication

A1

A2

Selection Filter

Environment

Changes in message ¿?
Ambient influence ¿?
The 2006 NASA ST5 spacecraft antenna

An example of an evolved X-band antenna evolved for a 2006 NASA mission called Space Technology 5 (ST5).

Its complicated shape was fully designed by an evolutionary algorithm used by a computer design program to optimise radiation parameters.

Perfect space communication due to a strange uneven shape suggested by a machine.

Source: NASA
My martian dog is running
Your martian dog will fly
\[\text{jump}\]
\[\text{volatilize}\]
Definitions of AI

What

- computer programs or machines that can learn, solve problems, and think logically
- a flexible agent which perceives its environment and takes actions to maximize its chance of success at some goal or objective
- A computer program is said to learn from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E (Tom Mitchell, 1998)

How

- Systems that work on their own without being encoded with commands
- Systems that can improve its ability to solve a wide range of tasks without the injection of specific human knowledge for each of them
- Advanced statistical and heuristic algorithms
- Systems that can understand human speech, compete at a high level in strategic game systems, interpret complex data, recognize characters, images and faces...
- a system’s ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation (Kaplan and Haenlein)

Field of study that gives computers the ability to learn without being explicitly programmed (Arthur Samuel, 1959)

José Manuel Rey, 2014

the science and technology of producing intelligent machines (John McCarthy, 1955)
The Moravec’s Paradox

Credit: UC Berkeley Robot Learning Lab

Credit: RUDN University
AI Milestones

- **1642**: First mechanical calculating machine built by French mathematician and inventor Blaise Pascal.
- **1837**: First design for a programmable machine, by Charles Babbage and Ada Lovelace.
- **1943**: Foundations of neural networks established by Warren McCulloch and Walter Pitts, drawing parallels between the brain and computing machines.
- **1950**: Alan Turing introduces a test—the Turing test—as a way of testing a machine's intelligence.
- **1955**: 'Artificial intelligence' is coined during a conference devoted to the topic.
- **1965**: ELIZA, a natural language program, is created. ELIZA handles dialogue on any topic; similar in concept to today's chatbots.

**2009**

- Google builds the first self-driving car to handle urban conditions.

**2011-2014**

- iRobot launches Roomba, an autonomous vacuum cleaner that avoids obstacles.
- IBM's Watson defeats champions of US game show Jeopardy!
- Personal assistants like Siri, Google Now, Cortana use speech recognition to answer questions and perform simple tasks.

**2014**

- Ian Goodfellow comes up with Generative Adversarial Networks (GAN).
- AlphaGo beats professional Go player Lee Sedol 4-1.

**2016**

- Most universities have courses in Artificial Intelligence.

**2018**

- Computer program Deep Blue beats world chess champion Garry Kasparov.
- Edward Feigenbaum creates expert systems which emulate decisions of human experts.

The BRAIN

How our brains inspire AI

Will robots outsmart us?

https://qbi.uq.edu.au
AI Winters

**Boom 1**
“GOFAI”

**Winter 1**
- heuristic search
- General Problem Solver
- Samuels’ Checkers Program
- MIT, CMU, Simon, Newell, Stanford, McCarthy, Minsky

**Boom 2**
“Expert Systems”
- knowledge engineering
- DENDRAL, MYCIN, PROLOG, Lisp
- AAAI, JSAI
- FGCS, SCI, MCC, Alvey, ESPRIT
- Feigenbaum, Brooks

**Winter 2**

**Boom 3**
“Machine Learning”
- Social excitement and concern
- Success of AlphaGo, Libratus, etc...
- Deep Learning
- Autonomous Vehicles
- Autonomous Weapons
- “AI for Social Good”?

Chart from TechnologyStories.com
AI and friends...

José Manuel Rey, 2017
Symbolic AI (GOFAI) versus Numerical AI (Machine Learning)

In recent years, the gap is declining between symbolic and non-symbolic models.

A future hybrid paradigm would undoubtedly help us overcome the data intensity of neural networks and algorithms that are much better at reasoning, while also maintaining our ability to understand what’s going on under the hood.

Statistical Relational Artificial Intelligence
Fabrizio Riguzzi, Kristian Kersting, Marco Lippi and Sriraam Natarajan
Symbolic AI: Practical case
Automated Theorem Prover

[Online demonstration]
A general application for solving any type of practical first order logic problem

José Manuel Rey, 2002
Machine Learning

Adapted from http://www.cognub.com/index.php/cognitive-platform/
Natural Language Interfaces: Practical case
Virtual Assistant / Chatbot

[Online demonstration]
Mobile application: NLP Virtual Assistant for recreational and competitive sailing

José Manuel Rey, 2017
Virtual Assistant Example Application Modules

- **Speech Modules**
  - Speech to Text
  - Text to Speech

- **Natural Language**
  - AIML engine with extensions for syntax and semantics (using ontologies)
  - A basic factual database

- **GOBJP**
  - Modules
  - In a general case: Applications or interfaces to business processes

- **Knowledge Modules**

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Chatbots: Digital Workforce

Semantic Memory

Episodic Memory

Process Memory

Affective Memory

Virtual Assistant Platform: Example

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<tr>
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<th>Pleasure</th>
<th>Arousal</th>
<th>Dominance</th>
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<tr>
<td>Emotion</td>
<td>0.984</td>
<td>0.337</td>
<td>0.245</td>
</tr>
<tr>
<td>Mood</td>
<td>0.213</td>
<td>0.287</td>
<td>0.199</td>
</tr>
<tr>
<td>Personality</td>
<td>0.253</td>
<td>0.402</td>
<td>0.193</td>
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Satisfaction

0.907

+0.24
The perceptron

Source: Brains in Silicon group at Stanford university
\[ y = f(x_1, x_2) = 2 \left( \left( (x_1 > 0) \land (x_2 > 0) \right) \lor \left( (x_1 \leq 0) \land (x_2 \leq 0) \right) \right) - 1 \]

\[ y = 2((x_1 > 0) \ \text{XNOR} \ (x_2 > 0)) - 1 \]

\[ S(x) = \frac{1}{1 + e^{-x}} \]

José Manuel Rey, 2017
A “playground” for neural network design

https://playground.tensorflow.org
A mostly complete chart of Neural Networks

©2016 Fjodor van Veen - asimovinstitute.org

Fjodor van Veen, 2016
To be continued...
Facial Recognition

An annotated image from IBM’s Diversity in Faces dataset for facial recognition systems.

A Haar-like feature application (OpenCV)
www.researchgate.net uploaded by Kushairy kadir
Detecting & Identifying Faces

Source: FindFace

No database match

Caucasian Female
26 yo

Smile, 96%

Source: Face++

Source: FindFace
Impersonating Artists

Note: Original picture and images generated by an AI Neural Net model impersonating Joaquin Sorolla’s and Joan Miro’s painting styles (trained with MS-COCO dataset)

José Manuel Rey, 2017
Tesla Full Self Driving Chip

Radar - GPS - Maps - IMU - Ultrasonic - Wheel Ticks - Steering Angle

Source: Tesla and Samsung
Jul 20, 2016
DeepMind AI Reduces Google Data Centre Cooling Bill by 40%
Developed an AI-powered recommendation system to improve the energy efficiency of Google’s already highly-optimised data centres. “Our thinking was simple: even minor improvements would provide significant energy savings and reduce CO2 emissions to help combat climate change,” wrote Google data centre engineer Amanda Gasparik, DeepMind research engineer Chris Gamble, and DeepMind team lead Jim Gao.

Aug 18, 2018
Google Trusts DeepMind AI To Manage Data Centre Cooling
Google is trusting an artificial intelligence (AI) system developed by DeepMind to stop its data centres around the world from overheating. "Now we're taking this system to the next level: instead of human-implemented recommendations, our AI system is directly controlling data centre cooling, while remaining under the expert supervision of our data centre operators. This first-of-its-kind cloud-based control system is now safely delivering energy savings in multiple Google data centres."
Text extraction, analysis, summarization and NL generation

- Anomaly Detection
- Summary Extractor
- Sentiment Analysis
- NL Report Generator

Semantic Search
Automated Table Extraction
Automatic Form Recognition
Compliance Tests
Symbol/Logo Extraction
Advanced Data Extraction
Accessibility
Reflow
Content Repurposing

Adapted from monkeylearn.com
Deep Learning + The Human Genome = Deep Genomics

The Human Genome Project (HGP)
The World’s Largest Collaborative Biological Project Took 13 Years To Complete and was a critical building block for Deep Genomics.

- **1990**
  - HGP Commences
  - The US Department of Energy and the NIH sponsor the project

- **2003**
  - HGP Completed
  - HGP cost approximately $3 Billion to complete and was funded by

- **2007**
  - Consumer Gene Sequencing
  - Gene sequencing is commercialized offered to consumer for the first time

- **2012**
  - Deep Learning Takes Off
  - AlexNet is the first neural network to win the ILSVRC competition

- **2014**
  - It Gets Cheaper
  - Gene sequencers are challenged to bring the price to < $1,000

- **2015**
  - Genomics & AI Meet
  - Using AI, companies are can process the data from the human genome

- Deep Genomics provides insights using genomic data and deep learning technology to enable the design of diagnostics and new therapies from personalized medicine to cancer treatments.

- Market Size Projected by 2024
  - $45B

- Deep genomics may prove to be one of the biggest disruptors to the healthcare industry

- While Deep Genomics is still in the early stages as an industry, there is a lot of opportunity for startups and established companies alike.

- Time will tell what new applications will emerge using AI and genomics.
https://www.youtube.com/watch?v=WXuK6gekU1Y
AlphaGo - The Movie | Full Documentary

Beyond human intuition
AlphaGo: The nature of the problem

• $3^{n^2}$ possible board positions, (about $2 \times 10^{170}$ Legal positions)
• An average game-tree complexity of $10^{360}$
• Search space is huge. Brute force search is not affordable
• “Impossible” for computers to evaluate who is winning (In some games like chess it is feasible to know the specific winner)
• It was thought to be impossible to find a good way to solve this problem effectively.
• It involves certain characteristics (long term planning, abstract intuition...) that were perceived as intractable for machines
AlphaGo
The neural network training pipeline

Adapted from deepmind.com
AI “skills” / tools

DISCOVERY
- Vision
  - OCR
  - Visual Recognition
  - Object detection
- Audio
  - Music recognition
  - Voice recognition
  - Voice/Tone analysis
- Data Insights
  - Semantic Search
  - Discovery
  - News retrieval
  - Anomaly Detection

INTERACTION
- Language
  - Conversation
  - Document Conversion
  - Language Translation
  - Natural Language Classifier
  - NL Processing
- Understanding
  - Prioritization and ranking
  - Sentiment analysis [text]
  - Facial expressions
  - Personality Insights
- Speech
  - Speech to Text
  - Text to Speech

DECISION
- Optimization
  - Trade-off Analysis
  - Complexity Reduction
  - Reinforcement Learning

APPLICATIONS
- Surveillance & Security
- Autonomous Vehicles
- Virtual Assistant or Chatbots
- Algorithmic Trading
- Robotic Process Automation
- Biometrics
- Health Monitoring & Diagnosis
- Biochemistry & Genetics
- IP Enforcement
- Fraud detection
- Anti-Spam Filtering
- “Deepfakes”
- Online Marketing
- Recommendation Engines
- Social research
- Cost optimization
- Process streamlining
- ...

José Manuel Rey, 2018
AI Rollout

Data Preparation

Data Analysis

Training Datasets

AI/Cognitive Platforms

Deployment

Model Validation

Model Training

Operations

Performance Measurement

Incremental Retraining

Third-party Components

Pretrained Models

Business & Organizational Alignment

José Manuel Rey, 2015
Attitude

• Some extent of uncertainty in the rhythm of delivered qualitative/quantitative results \(\rightarrow\) Balanced Experimentation
• Blackbox versus Explainability [until “Explainable AI” is reached]
• The rise of “fuzzy machines” and the decline of “illusion of delegation of high-precision and arbitrarily-deterministic calculations”
• Performance (Statistical metrics), Regulations (who is ultimately accountable for the decisions) and external visibility

Focus

• AI has revealed itself as excellent for internal process improvement but also for delivering some type of “consulting” as a service (using only your customer’s data but without deeply exploring its business model)

Collaboration

• AI projects require cooperation with knowledge and technological partners
• Academia versus Industry [type and scope of problems, deadlines, code quality]

Alignment

• Think big, plan solidly and act progressively
• If you build on realities rather than expectations your investment will be preserved

José Manuel Rey, 2015
Thank you very much for your attention
Adjust your sails for the new winds of Artificial Intelligence...
and enjoy the adventure of this voyage