A Timeline of Artificial Intelligence

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All of these events are explained in my book "Intelligence is not Artificial".

1960: Henry Kelley and Arthur Bryson invent backpropagation
1960: Donald Michie's reinforcement-learning system MENACE

1960: Hilary Putnam's Computational Functionalism ("Minds and Machines")

1960: The backpropagation algorithm

1961: Melvin Maron's "Automatic Indexing"
1961: Karl Steinbuch's neural network Lernmatrix

1961: Leonard Scheer's and John Chubbuck's Mod I (1962) and Mod II (1964)

1961: Space General Corporation's lunar explorer

1962: IBM's "Shoebox" for speech recognition
1962: AMF's "VersaTran" robot

1963: John McCarthy moves to Stanford and founds the Stanford Artificial Intelligence Laboratory (SAIL)

1963: Lawrence Roberts' "Machine Perception of Three Dimensional Solids", the birth of computer vision
1963: Jim Slagle writes a program for symbolic integration (calculus)

1963: Edward Feigenbaum's and Julian Feldman's "Computers and Thought"

1963: Vladimir Vapnik's "support-vector networks" (SVN)

1964: Peter Toma demonstrates the machine-translation system Systran
1965: Irving John Good (Isidore Jacob Gudak) speculates about "ultraintelligent machines" (the "singularity")

Irving John Good – 1960s
- The ultraintelligent machine

“A machine that can far surpass the intellectual activities of any man however clever. ... an ultraintelligent machine could design even better machines ... The intelligence of man would be left far behind.”

1965: The Case Institute of Technology builds the first computer-controlled robotic arm

1965: Ed Feigenbaum's Dendral expert system
1965: Gordon Moore's Law of exponential progress in integrated circuits
("Cramming more components into integrated circuits", 1965)

1965: Herbert Simon predicts that "Machines will be capable, within 20 years, of doing any work a man can do"
1965: Hubert Dreyfus's "Alchemy and Artificial Intelligence"

1965: Lotfi Zadeh's Fuzzy Logic

1965: Alexey Ivakhnenko publishes the first learning algorithms for multi-layered networks

1965: Bruce Lacey's robot Rosa Bosom at the Cybernetic Serendipity exhibition of computer art
1966: Robert McGhee's "Phony Pony" four-legged robot

1966: Leonard Baum popularizes the Hidden Markov Model ("Statistical Inference for Probabilistic Functions of Finite State Markov Chains")
1966: Ross Quillian's semantic networks

1966: Joe Weizenbaum's Eliza

1966: ALPAC report on Machine Translation
1967: Charles Fillmore's Case Frame Grammar

1968: Glenn Shafer's and Stuart Dempster's "Theory of Evidence"
1968: Jerry Feldman's Hand-eye system

1969: Christopher Longuet-Higgins' associative memory

1969: Marvin Minsky & Samuel Papert's "Perceptrons" kill neural networks
1969: First International Joint Conference on Artificial Intelligence (IJCAI) at Stanford
1969: Stanford Research Institute's Shakey the Robot (Nils Nilsson and others)
1969: Victor Scheinman's "Stanford arm"

1969: Roger Schank's Conceptual Dependency Theory for natural language processing

- **ATRANS**: Transfer of an abstract relationship (e.g., give)
- **PTRANS**: Transfer of the physical location of an object (e.g., go)
- **PROPEL**: Application of physical force to an object (e.g., push)
- **MOVE**: Movement of a body part by its owner (e.g., kick)
- **GRASP**: Grasping of an object by an action (e.g., throw)
- **INGEST**: Ingestion of an object by an animal (e.g., eat)
- **EXPUL**: (e.g., cry)
- **MTRANS**: Transfer of mental information (e.g., tell)
- **MBUILD**: Building new information out of old (e.g., decide)
- **SPEAK**: Producing of sounds (e.g., say)
- **ATTEND**: (e.g., listen)

1969: Cordell Green's automatic synthesis of programs

1969: John McCarthy's "Some Philosophical Problems from the Standpoint of Artificial Intelligence" and the frame problem
1970: Albert Uttley's Informon for adaptive pattern recognition

1970: Hitachi demonstrates a robot that can build objects based on drawings

1970: Tom Martin founds Threshold Technology, the first commercial company for speech recognition

1970: William Woods' Augmented Transition Network (ATN) for natural language processing
1971: The "Stanford cart" autonomous outdoors vehicle


1971: Richard Fikes' and Nils Nilsson's STRIPS planner

1971: Noam Chomsky's article against Burrhus Skinner's behaviorism
1971: Ingo Rechenberg publishes his thesis "Evolution Strategies", a set of optimization methods for evolutionary computation

1971: University of Edinburgh's robot Freddy

1972: Alain Colmerauer's PROLOG programming language

1972: The first chatbot to chatbot conversation ever takes place over the Arpanet between Kenneth Colby's chatbot Parry at Stanford and Eliza at MIT
1972: Richard Karp shows there are many problems that can probably only be solved in exponential time

1972: Harry Klopf's "Brain Function and Adaptive Systems"

1972: William Woods' question-answering system LUNAR

1972: The SIRCH robotic arm at Nottingham University
1972: Bruce Buchanan's MYCIN

1972: Terry Winograd's Shrdlu
1972: Shigeo Hirose's snake-robot ACM III

1972: Petternella-Salinari hexapod robot

1973: "Artificial Intelligence: A General Survey" by James Lighthill criticizes Artificial Intelligence for over-promising
1973: Ichiro Kato's Wabot, the first real-size anthropomorphic walking robot

1973: Antal Bejczy's JPL Rover

1973: Jim Baker applies the Hidden Markov Model to speech recognition ("Machine-aided Labeling of Connected Speech")
1974: Marvin Minsky's frame

A Framework for Representing Knowledge

Marvin Minsky

1974: Paul Werbos' backpropagation algorithm for neural networks

1975: Roger Schank's script

Restaurant Script (Schank & Abelson, 1975)

1975: Ben Skora's robot Arok
1975: Raj Reddy's team at Carnegie Mellon University develops three speech-recognition systems (Bruce Lowerre's Harpy, Hearsay-II and Jim Baker's Dragon)

1975: Hearsay-II's blackboard model by Rick Hayes-Roth, Lee Erman, Victor Lesser and Richard Fennell

1975: The first Artificial Intelligence in Medicine workshop at Rutgers University
1975: John Holland's genetic algorithms

1976: Richard Laing's paradigm of self-replication by self-inspection
1976: Stephen Grossberg's Adaptive Resonance Theory (ART) for unsupervised learning

1976: Fred Jelinek's "Continuous Speech Recognition by Statistical Methods"
1976: Shigeo Hirose's Kumo-I (1976) and PV-II (1978)

1976: Masha hexapod

1977: Robert McGhee's Bionic Bug

1977: Georges Giralt's Hilare robot in France
1977: General Motors' computer-vision system Sight-I

1977: Ian Witten's actor-critic method

1977: David Marr's and Tomaso Poggio's "2 1/2 sketch"

1978: John McDermott's expert system R1/XCON
1978: Shunichi Amari publishes neural field equations

1978: Ryszard Michalski builds the first practical system that learns from examples, AQ11

1978: Lothar Rossol organizes at General Motors a symposium on computer vision

1979: Johan DeKleer's qualitative reasoning
1979: A factory worker named Robert Williams is the first human killed by a robot
1979: General Motors' Consight robot
1979: Tokuji Okada's robotic hand with three fingers

1979: William Clancey's Guidon

1979: Hans Berliner's BKG 9.8 at Carnegie-Mellon University (connected by satellite to the robot Gammonoid) beats the world champion of backgammon in Monte Carlo

1979: Drew McDermott's non-monotonic logic

1979: Kunihiko Fukushima's convolutional neural network ("Neocognitron - A Self-
organizing Neural Network Model for a Mechanism of Pattern Recognition Unaffected by Shift in Position"

1980: McCarthy's Circumscription

1980: John Searle's article "Minds, Brains, and Programs" on the "Chinese Room" that attacks Artificial Intelligence

1980: IntelliGenetics (Intelicorp), the first major start-up for Artificial Intelligence

1981: Automatix introduces the first commercial robot with a vision system
1981: Russell Andersson's robot SCIMR

1981: Danny Hillis' Connection Machine

1981: Hans Kamp's Discourse Representation Theory

1981: Japan has 14,000 industrial robots versus the USA's 4,200 and West Germany's 2,300

1982: The Parallel Distributed Processing (PDP) research group at UC San Diego

1982: Shunichi Mizuno's cybot New Monroe
1982: Hans Moravec's CMU Rover

1982: Kenneth Salisbury (Stanford) & Jet Propulsion Laboratory's robotic hand

1982: John Hopfield describes a new generation of neural networks, based on recurrence

1982: The Canadian Institute for Advanced Research (CIFAR) establishes Artificial Intelligence and Robotics as its very first program

1982: Bart Everett's robot Robart I
1982: Japan's Fifth Generation Computer Systems project

Computer generations:
- 0th generation: 500 B.C., mechanical gears.
- 1st generation: 1940's, vacuum tubes.
- 2nd generation: 1950's, transistors.
- 3rd generation: 1960's, integrated circuits [ICs].
- 4th generation: Microprocessors.
- FGCS, Fifth Generation Computer Systems project.

1982: Teuvo Kohonen's Self-Organized Maps (SOM) for unsupervised learning

1982: Judea Pearl's "Bayesian networks"

1982: David Parker rediscovers backpropagation

1982: Joseph Bosworth's personal robot RB5X
1983: Dainichi Kiko's waiter robot

1983: Scott Kirkpatrick's simulated annealing

1983: Mike Cohen's and Stephen Grossberg's continuous recurrent networks

1983: Yurii Nesterov's accelerated version of gradient descent ("Nesterov momentum")
1983: John Laird and Paul Rosenbloom's SOAR

1983: Geoffrey Hinton's and Terry Sejnowski's Boltzmann machine

1983: Gerard Salton and Michael McGill's "Introduction to Modern Information Retrieval" (the "bag-of-words model")

1983: Odetics' Odex

1984: Tomy's toy Omnibot 2000
1984: Mike Forino's personal robot Hubot

1984: Valentino Braitenberg's "Vehicles"

1984: Robotic hand by Stephen Jacobsen (Univ of Utah) & MIT
1984: Doug Lenat's "Cyc" to catalog common sense

1984: Barbara Hayes-Roth's general-purpose blackboard system BB1

1985: Ichiro Kato's Wasubot performs with a symphony orchestra

1985: Ross Quinlan's ID3 for decision trees analysis
1985: The first international conference on genetic algorithms

1985: Piero Scaruffi opens the A.I. Center at Olivetti, the first major non-academic A.I. Center outside the USA

1985: Yann LeCun rediscovers backpropagation

1985: Rodney Brooks' subsumption architecture for robots
1986: Terrence Sejnowski's and Charles Rosenberg's NETtalk

1986: Hinton and Sejnowski organize the first "Connectionist Summer School" at CMU

1986: Jeanny Herault's and Christian Jutten's independent component analysis

1986: David Zipser's "autoencoder"

1986: David Rumelhart, Geoffrey Hinton and Ronald Williams rediscover Werbos' backpropagation algorithm
equations of backpropagation

$$\delta^L = \nabla_a C \odot \sigma'(z^L)$$

$$\delta^l = \left((w^{l+1})^T \delta^{l+1}\right) \odot \sigma'(z^l)$$

$$\frac{\partial C}{\partial w^l_{jk}} = \delta_j$$

$$\frac{\partial C}{\partial w^l_{jk}} = a^{l-1}_k \delta_j^l$$

1986: David Rumelhart's and Jay McClelland's book "Parallel Distributed Processing"

1986: Paul Smolensky's Restricted Boltzmann machine

Restricted Boltzmann Machine

$$E(v,h) = -b'v - d'h - h'Wv$$

$$F(v) = -b'v - \sum_i \log \sum_{h_i} e^{h_i(c_i + W_iv)}$$

1986: Barbara Grosz's "Attention, Intentions, and the Structure of Discourse"
1987: Hinton moves to the Canadian Institute for Advanced Research (CIFAR)

1987: Dana Ballard uses unsupervised learning to build representations layer by layer

1987: Chris Langton coins the term "Artificial Life"
1987: Marvin Minsky's "Society of Mind"

1988: Hilary Putnam: "Has artificial intelligence taught us anything of importance about the mind?"
1988: Toshio Fukuda's self-reconfiguring robot CEBOT

1988: Dean Pomerleau's self-driving vehicle ALVINN


1988: Philip Agre builds the first "Heideggerian AI", Pengi, a system that plays the arcade videogame Pengo

1988: Fred Jelinek's team at IBM publishes "A Statistical Approach to Language Translation"
1989: Alex Waibel's "time-delay" neural network

1989: Chris Watkins' Q-learning

1989: Rodney Brooks' six-legged Genghis

1989: George Cybenko proves that neural networks can approximate continuous functions

1989: Yann LeCun's convolutional neural network for handwritten-digit recognition (LeNet-1)

1989: Kurt Hornik proves that neural networks are universal approximators

1990: Carver Mead describes a neuromorphic processor
1990: Robert Jacobs' "mixture-of-experts" architecture

1990: Robert Schapire's "boosting" for machine learning

1990: Peter Brown at IBM implements a statistical machine translation system

1990: Ray Kurzweil's book "Age of Intelligent Machines"

1991: Youstol Dispage Frompiero discovers inverted correlation
1991: Isabelle Guyon adapts Vapnik's support vector machine (SVM) to pattern classification
1992: Hava Siegelmann and Eduardo Sontag prove that recurrent neural networks are equivalent to Turing machines

1992: Ron Williams' REINFORCE algorithm
1992: Long-ji Lin's "experience replay" algorithm for reinforcement learning

1992: Hava Siegelmann's and Eduardo Sontag's Analog Recurrent Neural Networks

1993: Masayuki Inaba's remote-brained robots

1993: Rodney Brooks' Cog robot
1993: Tom Mitchell's Xavier robot

Xavier

1994: The first "Toward a Science of Consciousness" conference in Tucson, Arizona

1994: Ernst Dickmanns' self-driving car drives more than 1,000 kms near the airport Charles-de-Gaulle in Paris
1994: Jonathan Schaeffer's Chinook wins the world championship of checkers

1995: Tin-kam Ho's random decision forests

1995: First "No Free Lunch" theorem by David Wolpert

1996: Honda's humanoid robot P2
1996: David Field & Bruno Olshausen's sparse coding

1996: Atsuo Takanishi's Wabian (WAseda BIpedral humANoid)

1997: Jeurgen Schmidhuber's and Sepp Hochreiter's Long Short Term Memory (LSTM) model
1997: NASA's Mars Pathfinder lands on Mars and deploys the first roving robot, Sojourner

1997: IBM's "Deep Blue" chess machine beats the world's chess champion, Garry Kasparov

1998: Yann LeCun's LeNet-5
1998: Sebastian Thrun's Minerva and Pearl robots

1998: Thorsten Joachims' "Text Categorization With Support Vector Machines"

1998: Two Stanford students, Larry Page and Russian-born Sergey Brin, launch the search engine Google

2000: Cynthia Breazeal's emotional robot, "Kismet"
2000: Seth Lloyd's "Ultimate physical limits to computation"
2000: Hirochika Inoue's humanoid robot H6

2000: Honda's humanoid robot "Asimo"
2001: Juyang Weng's "Autonomous mental development by robots and animals"
2001: Herbert Jaeger's echo state networks
2001: Nikolaus Hansen introduces the evolution strategy called "Covariance Matrix Adaptation" (CMA) for numerical optimization of non-linear problems
2001: Yoshua Bengio's "Neural Probabilistic Language Model"
2002: iRobot's Roomba
2002: Wolfgang Maass and Henry Markram's liquid state machines

2002: Ronan Collobert develops the deep-learning platform Torch

2003: Hiroshi Ishiguro's Actroid, a robot that looks like a young woman
2003: Jackrit Suthakorn and Gregory Chirikjian build an autonomous self-replicating robot
2003: Gabriela Csurka's bag-of-features
2003: Tai-Sing Lee's "Hierarchical Bayesian inference in the visual cortex"
2003: DARPA's assessment of progress in speech recognition
2003: Klaus Loeffler's humanoid robot Johnnie

2004: Mark Tilden's biomorphic robot Robosapien
2005: Jun-ho Oh's humanoid robot Hubo

2005: Hod Lipson's "self-assembling machine" at Cornell University

2005: Patrice Simard uses GPUs to implement a neural network

2005: Andrew Ng at Stanford launches the STAIR project (Stanford Artificial Intelligence Robot)
2005: Sebastian Thrun's driverless car Stanley wins DARPA's Grand Challenge
2005: Pietro Perona's and Fei-Fei's "A Bayesian Hierarchical Model for Learning Natural Scene Categories"
2005: Boston Dynamics' quadruped robot "BigDog"

2006: The Monte Carlo tree search algorithm
2006: Scott Hassan founds robot startup Willow Garage
2006: Alex Graves' connectionist temporal classification (CTC)

2006: Osamu Hasegawa's Self-Organising Incremental Neural Network (SOINN), a self-replicating neural network for unsupervised learning

2007: Stanford unveils the Robot Operating System (ROS)

2008: Dharmendra Modha at IBM launches a project to build a neuromorphic processor
2008: Oriza Hirata's theatrical play "Hataraku Watashi/ I Worker" features a robot

2008: Cynthia Breazeal's team at the MIT's Media Lab unveils Nexi, the first mobile-dexterous-social (MDS) robot

2009: Fei-fei Li's ImageNet database of human-tagged images

2009: ARPA's assessment of progress in speech recognition

2010: The first ImageNet challenge
2010: Demis Hassabis, Shane Legg and Mustafa Suleyman found DeepMind

2010: The New York stock market is shut down after algorithmic trading has wiped out a trillion dollars within a few seconds.

2010: James Kuffner coins the term "cloud robotics"

2010: Daniela Rus' "Programmable Matter by Folding"

2010: Lola Canamero's Nao, a robot that can show its emotions
2011: Nick D'Aloisio releases the summarizing tool Trimit (later Summly) for smartphones
2011: Dong Yu's speech recognition using deep learning

2011: IBM's Watson debuts on a TV show

2011: Osamu Hasegawa's SOINN-based robot that learns functions it was not programmed to do
2012: Rodney Brooks' hand programmable robot "Baxter"

2012: The Open Source Robotics Foundation is launched
2012: Andrew Ng's team demonstrates an unsupervised neural network that recognizes cats in videos
2012: Alex Krizhevsky and Ilya Sutskever from the University of Toronto demonstrate that deep learning outperforms traditional approaches to computer vision processing 200 billion images during training (AlexNet)

2013: Nal Kalchbrenner's and Phil Blunsom's "sequence to sequence" learning
2013: Volodymyr Mnih's Deep Q-Networks
2013: Max Welling's and Diederik Kingma's variational autoencoders

2013: Tomas Mikolov's Word2vec

2013: Yangqing Jia develops the deep-learning platform Caffe

2013: Ross Girshick's Region-based Convolutional Neural Networks (R-CNN)

2013: Piero Scaruffi's "Intelligence is not Artificial"
2014: Vladimir Veselov's and Eugene Demchenko's program Eugene Goostman, which simulates a 13-year-old Ukrainian boy, passes the Turing test at the Royal Society in London.

2014: Karen Simonyan's and Andrew Zisserman's VGG-16

2014: Kyunghyun Cho's encoder-decoder model and gated recurrent units (GRUs)
2014: Christian Szegedy's GoogLeNet

2014: Volodymyr Mnih's recurrent attention model (RAM)

2014: Ian Goodfellow's generative adversarial networks

2014: Alex Graves' LSTM without Hidden Markov Models for speech recognition

Towards End-to-End Speech Recognition with Recurrent Neural Networks

minimise the CTC objective function

$$CTC(x) = -\log \Pr(y^*|x)$$
2014: Ilya Sutskever and Oriol Vinyals use a recurrent neural network to improve machine translation at Google ("Sequence to Sequence Learning with Neural Networks")

2014: Microsoft introduces the text chatbot Xiaoice in China
2014: Andrey Karpathy's and Fei-Fei Li's computer vision algorithm that can describe photos ("Deep Visual-Semantic Alignments for Generating Image Descriptions", 2014)

2014: Alex Graves, Greg Wayne and Ivo Danihelka publish a paper on "Neural Turing Machines"
2014: Jason Weston, Sumit Chopra and Antoine Bordes publish a paper on "Memory Networks"

2014: Microsoft's Skype demonstrates a real-time spoken language translation system
2014: Google buys DeepMind, founded by Demis Hassabis and Shane Legg

2015: Baidu's Deep Speech 2 that uses a GRU instead of a LSTM and no HMM

2015: Francois Chollet develops the deep-learning platform Keras

2015: Microsoft's 152-layer Residual Net
2015: Rajat Monga's team develops the deep-learning platform TensorFlow

2015: Seiya Tokui develops the deep-learning platform Chainer

2015: Over 1,000 high-profile Artificial Intelligence scientists sign an open letter calling for a ban on "offensive autonomous weapons"

2015: Leon Gatys, Alexander Ecker and Matthias Bethge's "A Neural Algorithm of Artistic Style"

2015: Alec Radford's deep convolutional generative adversarial networks
2016: Ronen Eldan and Ohad Shamir prove that "depth can be exponentially more valuable than width"

2016: DeepMind's AlphaGo, developed by Aja Huang, beats Go master Lee Se-dol

2016: Kaiming He's ResNet with identity mappings of 1001 layers

2016: Jianpeng Cheng's and Mirella Lapata's self-attention
2017: Google's "transformer" model for sentence analysis (Ashish Vaswani, Noam Shazeer, Jakob Uszkoreit)

2017: DeepMind's AlphaGo Zero and AlphaZero

2017: Alexei Efros' team generates images from sketches with Pix2pix

2017: More than 100 variants of generative adversarial networks are introduced in 2017

2017: John Schulman's proximal policy optimization for reinforcement learning
2018: Ali Eslami's and Danilo Rezende's Generative Query Network - GQN

2018: OpenAI's OpenAI Five

2018: Xiaolong Wang's nonlocal neural networks

2018: Jeremy Howard's and Sebastian Ruder's ULMFiT
2018: David Duvenaud’s Neural ODEs

Neural Ordinary Differential Equations

Algorithm 1 Reverse-mode derivative of an ODE initial value problem

Input: dynamics parameters \( \theta \), start time \( t_0 \), stop time \( t_f \), final state \( z(t_f) \), loss gradient \( \partial L / \partial z(t_f) \)

1. Compute gradient w.r.t. \( t_f \)
2. Define initial augmented state
3. Define dynamics on augmented state
4. Concatenate time-derivatives
5. Solve reverse-time ODE
6. Return all gradients

2018: Jacob Devlin’s BERT for reading comprehension
BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding

Jacob Devlin  Ming-Wei Chang  Kenton Lee  Kristina Toutanova
Google AI Language

2019: OpenAI's GPT2 creates convincing articles
Language Models are Unsupervised Multitask Learners

Alec Radford  Jeffrey Wu  Rewon Child  David Luan  Dario Amodei  Ilya Sutskever
OpenAI

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