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Robots and Human-Robot Interaction Looking Back & Forth Robot follows user's gaze point on the screen. Also user can use 4 way controls for precise motion





laurecia





- Looking back at History
 - Computing

MICLOSOIL WIPPO

- Automata
- Robot/Android
- Computers
- Artificial Intelligence
- AR/VR

Case Study on XR based HRI

Live Video Feed on the System

REFOR PRODUC



Short Biography

- Assistant Professor at Centre for Product Design and Manufacturing and Associate Faculty at Robert Bosch Centre for Cyber Physical System, Indian Institute of Science
- Co-Chairman of IRG AVA, FG Smart TV at International Telecommunication Union, UNO
- Member, UKRI International Development Peer Review College
- PhD in Computer Science from Trinity College, University of Cambridge, UK
- Senior Research Associate at Cambridge University Engineering Department and Governing Body Fellow at Wolfson College
- Worked with Jaguar Land Rover, Technicolor, BAE Systems from 2010 – 16
- Principal Investigator of projects funded by Microsoft, Facebook, British Telecom, Faurecia, HAL, DRDO, ISRO HSF, and Wipro







Acknowledgement



History refers to events that did happen; drama to events that did not happen, but could have; and fabula to events that could not have happened, because they recount things that are contrary to nature

Isidore of Seville (ca 560-636)

First Robot in Western World

- Hephaestus is the Greek god of blacksmiths, metalworking, carpenters, craftsmen, artisans, sculptors, metallurgy, fire (compare, however, with Hestia), and volcanoes
- According to Homer, he made wheeled servants and female assistants endowed with sense, speech and strength

Ktesibios and the Alexandrian School

- BCE third century
- Technical manual on
 - Force pump
 - Catapult powered by compressed air
 - Water powered organs
 - Pneumatic birds





DI HERONE Alefsandrino E GLI AVTOMATI ACHINE SE MOVENT Libridue, Tradotti dal Greco da BERNARDINO BALDI Abbate di Guastalla. ON PRIVILEGIO

Automaton Making – Hero of Alexandria

- BCE first century
- Mobile shrine of Dionysus
- Small fixed theatre
- Converting one type of motion to another

Antikythera Mechanism

- The Antikythera mechanism is an ancient Greek hand-powered orrery, described as the oldest example of an analogue computer used to predict astronomical positions and eclipses decades in advance
- Discovered in shipwreck in Aegan Sea
- Kept at the National Archaeological Museum in Athens
- 80 BCE ~ 150 BCE

Outside Europe

<u>Hindu and Buddhist texts</u> describe the automaton warriors whirling like the wind, slashing intruders with swords, recalling Ajatasatru's war chariots with spinning blades. In some versions the robots are driven by a water wheel or made by Visvakarman, the Hindu engineer god. But the most striking version came by a tangled route to the "<u>Lokapannatti</u>" of Burma – Pali translations of older, lost Sanskrit texts, only known from Chinese translations, each drawing on earlier oral traditions.

In this tale, many "yantakara," robot makers, lived in the Western land of the "Yavanas," Greek-speakers, in "Roma-visaya," the Indian name for the Greco-Roman culture of the Mediterranean world. The



A statue of Visvakarman, the engineer of the universe. Suraj Belbase/Wikimedia Commons, CC BY-SA

Yavanas' secret technology of robots was closely guarded. The robots of Romavisava carried out trade and farming and captured and executed criminals

- In Ancient Egypt, statues with moving head played important role in religious ceremonies (BCE 16th -15th)
- The Buddhist scholar Daoxuan (596-667 AD) described humanoid automata crafted from metals that recite sacred texts in a cloister which housed a fabulous clock.
- The Indian Lokapannatti, a collection of cycles and lores produced in the 11th or 12th centuries AD, tells the story of how an army of automated soldiers (bhuta vahana yanta or "Spirit movement machines") were crafted to protect the relics of Buddha in a secret stupa
- Chinese carpenter Lu Ban and the philosopher Mozi described mechanical imitations of animals and demons.
- The implications of humanoid automatons were discussed in Liezi (4th century CE), a compilation of Daoist texts.

Outside Europe



Samarangana Sutradhara, a Sanskrit treatise by Bhoja (11th century), includes a chapter about the construction of mechanical contrivances (automata), including mechanical bees and birds, fountains shaped like humans and animals, and male and female dolls that refilled oil lamps, danced, played instruments, and reenacted scenes from Hindu mythology

13th century Muslim Scientist Ismail al-Jazari created several automated devices. He built automated moving peacocks driven by hydropower.

He also invented the earliest known automatic gates, which were driven by hydropower, created automatic doors as part of one of his elaborate water clocks.

One of al-Jazari's humanoid automata was a waitress that could serve water, tea or drinks.

Migration to Western World





- Alexander the Great's travel and conquest (BCE 300)
- Megasthenes' visit to India
- King Ashoka's quest for automated army
- Charlemagne and his baron's travel to Constantinople (CE 1200)
- Appearance of Mongol's in Balkans in (CE 1300)





Water Clock of Harun al-Rashid

- Caliph of Baghdad, early ninth century
- Sent elaborate Water Clock with moving figure to Charlemagne, the holy Roman Emperor

Humanoids



Plate 8. Lancelot battles the copper knights just before finding the box that contains the enchantments over the castle. These figures are naked, with chest and armpit hair, as well as genitalia. Lancelot, a human knight wearing a metal suit, is completely covered. *Lancelot do lac*, France, ca. 1470. Paris, BnF, MS Fr. 112, fol. 78.



Plate 10. Two youths guard the bridge in the *Roman d'Alexandre*. Alexander and his army approach from the left. The rubricated text reads: "Comment alixendre e la gent furent au bois as pucelles faees." *Le Roman d'Alexandre*, Paris, fourteenth century. Paris, BnF, MS Fr. 791, fol. 58v.



Plate 9. Lancelot battles the automata to enter Doloreuse Garde. Again, Lancelot is covered in metal, with no distinguishing physical characteristics. The automata have human faces and fairly undefined bodies. *Lancelot do lac*, France, fifteenth century. Paris, BnF, MS Fr. 118, fol. 200v.



Plate 11. Alexander encounters two golden automata guarding the bridge to the Bois des Puceles. The rubricated text reads: "Comment alexandre trovea le pont ouer .ii. ymages dor et tres beel." *Le Roman d'Alexandre*, French, illuminated by the Flemish painter Jehan de Grise and his school, ca. 1338–1344. Oxford, The Bodleian Libraries, University of Oxford, MS Bodley 264, fol. 70v.

HESDIN UNDER BURGUNDIAN PATRONAGE THE RESTORATIONS OF 1431



- Eight hidden water jets at the entrance which soaked visitors from below
- Trick mirror which sprayed white flour or black soot
- A room with an artificial thunderstorm: rain from above with flashes of lightning, sounds of thunder, and even snow

(how this was accomplished is an open question)

- Numerous hidden jets through the park that left visitors soaked with no possibility of escape
- By 1464, a rotating house was the site of a diplomatic embassy

Jean Miélot's illuminated manuscripts furnish glimpses of Hesdin under the Burgundian dukes

Marvels of Hesdin

• At the end of the 11th century, Hesdin gained renown for the park and chateau of Robert II, Count of Artois, which featured the earliest examples of early medieval automata in Europe

The Word *Automaton*

- François Rabelais born between 1483 and 1494; died 1553) was a French Renaissance writer, physician, Renaissance humanist, monk and Greek scholar born between 1483 and 1494; died 1553) was a French Renaissance writer, physician, Renaissance humanist, monk and Greek scholar
- He used the word 'Automate' to denote a machine with a self-contained principle of motion in *Gargantua* (1532)



Talking Heads

- The first Oracular Head is credited to Pope Sylvester II, earlier Gerbert de Aurillac
- Legend of Roger Bacon's Brazen head: *"Time is. Time was. Time is past"*

CERDERT SVLVESTRE I PREMIER PAPE PRANÇAIS RORT & RORE EN 1003 L'AUVERGNE SA PATRIE

NA CLUE LE 16 OCTOURE 185 TAR LES SOURS DE P. GUOCNUER ANCHEN RAME ET LA RURICUPALITÉ D'AUBULLAC



Humanoid Automata in 1400-1900

Calculators and Analog Computer





The Term Robot

- Robot' was first applied as a term for artificial automata in the 1920 play R.U.R. by the Czech writer, Karel Čapek. However, Josef Čapek was named by his brother Karel as the true inventor of the term robot.
- The word 'robot' itself was not new, having been in the Slavic language as robota (forced labor), a term applied to peasants obligated to compulsory service under the feudal system
- The Robot Patent is an English-language scholarly term for the imperial decrees (patents) in the 1700s abolishing compulsory labor (robot) of serfs, issued by Joseph II, Holy Roman Emperor, who had carried out a register of all land with a division between peasant and noble holdings

Artificial Intelligence – Modern Age

- Formal Reasoning
- Computer Science and Programming
- Turing Test
- Game Al
- Neural Network
- Symbolism
- 1956 workshop at Dartmouth College
- General Problem Solver (GPS)

- Goal Directed Adaptive
 Behaviour
- If a machine could carry on a conversation (over a <u>teleprinter</u>) that was indistinguishable from a conversation with a human being, then it was reasonable to say that the machine was "thinking".
- "every aspect of learning or any other feature of intelligence can be so precisely described that a machine can be made to simulate it"

Early Computers





Modelling Human



Warren McCulloch



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PAUL M. FITTS



Walter Pitts

Figure 1. Reciprocal tapping apparatus. The task was to hit the center plate in each group alternately without touching either side (error) plate.



BROWN BAGS

CMU MAIN CALENDAR OF EVENTS PAGE

CMU OFFICIAL HOLIDAYS

 O The 36th Carnegie Mellon Symposium on Cognition (June 2-3, 2009) "Expertise and Skill Acquisition: The Impact of William G. Chase"
 -J. R. Anderson, M. A. Just, R. S. Siegler, & J. J. Staszewski

<u>web-page</u>

 The 35th Carnegie Mellon Symposium on Cognition (2008) "Development and Brain Systems in Autism"
 Marcel Just & Kevin Pelphrey, Organizers

<u>web-page</u>

O The 34th Carnegie Mellon Symposium on Cognition (2004) "Embodiment, Ego-space, and Action" -Klatzky, MacWhinney & Behrmann



web-page publication information

Holistic Picture

Dendral

- The Dendral system (DENDRitic ALgorithm) was the first expert system, developed in the 1960s
 - Determines chemical composition from mass spectrogram data
- Plan-generate-and-test with human feedback
- This is a constrained search technique
 - Generate a hypothesis: a possible chemical compound
 - Test the hypothesis: use a series of heuristics and subprograms to determine if the chemical compound generated is plausible given the data
 - If so, show it to the user the user can steer the direction that DENDRAL takes next by suggesting what chemical elements should be added or removed from the generated hypothesis compound
 - DENDRAL repeats until an answer is found acceptable that does not violate the constraints as dictated by the data

Eliza

- Created by Joseph Weizenbaum at MIT
- Weizenbaum wrote the program so that it would generate an English response/question based on a group of patterns
- The most famous script, DOCTOR, simulated a Rogerian psychotherapist (in particular, Carl Rogers, who was well-known for simply parroting back at patients what they had just said), and used rules, dictated in the script, to respond with non-directional questions to user inputs.
- As such, ELIZA was one of the first chatterbots and one of the first programs capable of attempting the Turing test.

- Sample dialog:
 - H: Men are all alike
 - E: In what way?
 - H: They're always bugging us about something or another.
 - E: Can you be more specific?
 - H: Well, my boyfriend made me come here.
 - E: Your boyfriend made you come here?
 - H: He says I'm depressed much of the time.
 - E: I am sorry to hear you are depressed.
 - H: It's true. I am unhappy.
 - E: Do you think coming here will help you not to be unhappy?
 - H: I need some help, that much seems certain.
 - E: What would it mean to you if you got some help?
 - H: Perhaps I could learn to get along with my mother.
 - E: Tell me more about your family

MYCIN

- Implemented in the early 1970s, Mycin is perhaps the most recognized and cited expert system
- MYCIN was developed over five or six years in the early 1970s at <u>Stanford University</u>. It was written in <u>Lisp</u> as the doctoral dissertation of <u>Edward Shortliffe</u> under the direction of Bruce G. Buchanan, <u>Stanley</u> <u>N. Cohen</u> and others.
- MYCIN operated using a fairly simple inference engine and a knowledge base of ~600 rules.
- MYCIN received an acceptability rating of 65% on treatment plan from a panel of eight independent specialists
- MYCIN was never actually used in practice

Model Human Processor







Interactive Systems



Immersive User Experience

Sensorama Simulator

Sword of Damocles

Boeing System



Case Study – Immersive Media for Intelligent Human Robot Interaction

Live Video Feed on the System

Multimodal Robot Controller Demo for Hannover Messe 2019



Multimodal Robot Invention Disclosure : IISc-IISc 2019

Live Video Feed on the System

Eye Gaze and Augmented Reality based Human Robot Interaction

Gaze Controlled Safe HRI for Users with SSMI

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App Cpu/Gpu: 11.52/0.58ms 50.77Hz Pre Cpu/Gpu: 0.04/0.03ms Post Cpu/Gpu: 0.95/5.06ms 49.96Hz Pose Age: 53.47 ms Compositor Type: Passthru Cpu/Gpu Status: 1/1 Warning/Error: None

0

App Cpu/Gpu: 23.62/3.60ms 29.84Hz Pre Cpu/Gpu: 0.06/0.00ms Post Cpu/Gpu: 1.02/6.04ms 29.61Hz Pose Age: 67.35 ms Compositor Type: Passthm Cpu/Gpu Status: 1/1 Warning/Error: None

E

E

Transmission in contrastic

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App Cpu/Gpu: 11.79/1.87ms 38.90Hz Pre Cpu/Gpu: 0.04/0.03ms Post Cpu/Gpu: 0.62/3.22ms 38.31Hz Varning/Error: None

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12/1

EEE



Summary

- *Automata* refers to machines with self-contained or self-sustaining principle of motion
- Mechanical, pneumatic or hydraulic automated machines appeared in mythology from 300 BCE or even earlier
- Early systems took the form of
 - Humanoid
 - Animals, Birds
 - Fountain, Clock and so on
- Purpose was

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- Guarding
- Decoration
- Showing supernatural ability
- Astronomical calculation etc.
- Often associated with significant social fear, anxiety, superstition

ACM/IEEE HRI 22 Research Themes

- HUMAN-ROBOT INTERACTION USER STUDIES: The primary contribution is human-focused, e.g., how humans perceive, interact with, or otherwise engage with robots. This theme is for research contributions that provide new knowledge of human-robot interactions derived from data and analysis of humans and robots in laboratory or in-the-wild settings.
- TECHNICAL ADVANCES IN HUMAN-ROBOT INTERACTION: The primary contribution is robot-focused, e.g., systems, algorithms, or computational methods supporting HRI. This theme is for research contributions that provide novel robot systems, algorithms, interface technologies, and computational methods supporting human-robot interaction.
- HUMAN-ROBOT INTERACTION DESIGN: The primary contribution is design-focused, e.g., new morphologies, behavior paradigms, and interaction capabilities for robots.
- THEORY AND METHODS IN HUMAN-ROBOT INTERACTION: The primary contribution is theoretical or methodological, e.g., new ways of studying HRI, elucidating or connecting fundamental HRI principles beyond individual interfaces or projects, new theoretical concepts in HRI, literature reviews, work that focuses on reproducing, replicating, or recreating prior HRI work (or fails to), etc.
- SYSTEMS: The primary contribution is investigating or describing how underlying techniques come together to achieve system-level HRI behavior.