



Intelligent Machine-Human Communication Interfaces

by

R. C. Chakraborty

Visiting Professor at JIET, Guna.

Former Director of DTRL & ISSA (DRDO),

rcchak@gmail.com

www.myreaders.wordpress.com

December. 05, 2009

Annual National Conference of Vijnana Parishad of India

National Symposiun

'Recent Developments in Applicable Mathematics &

Information Technology'

December 4-6, 2009

at

Jaypee Institute of Engineering & Technology (JIET),

Guna – 473226

Intelligent Machine-Human Communication Interfaces

Highlights of my talk

- ▶ ***Timeline of Computer related technology***
- ▶ ***Timeline of Communication technology***
Modern digital communications
Internet era
- ▶ ***Timeline of AI events***
Artificial Intelligence
New Generation of AI
- ▶ ***Perspectives on AI : Myth and Speculation***
- ▶ ***Machine-Human Intelligence Interface***
- ▶ ***AI in Early 21st century***
- ▶ ***Technological Singularity***
- ▶ ***Intelligent Machine-Human Society***
- ▶ ***Conclusion***

Timeline of Computer related technology

5000 years ago, Roman Abacus, the machine with memory,



1652, Pascaline, calculating machines that mechanized arithmetic ,

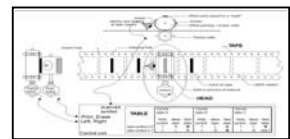


1849 , Diff. Engine, mechanical calculating machines programmable to tabulate polynomial functions.

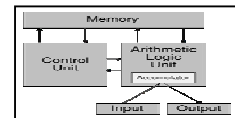


1854, Boolean algebra, " Investigation of laws of Thought" symbolic language of calculus.

1936, Turing machines, abstract symbol-manipulating devices, adapted to simulate the logic, is the first computer invented (on paper only).



1945, Von Neumann architecture, computer design model, a processing unit and a shared memory structure to hold both instructions and data.



1946, ENIAC, "Electronic Numerical Integrator and Calculator" the first electronic "general-purpose" digital computer by Eckert and Mauchly.



1950, UNIVAC, "UNIVersal Automatic Computer" the first commercial computer produced in USA, the size of a small bedroom(14x7x9 feet); a set of 5000 vacuum tubes made it work on a decimal (ten-digit) system rather than a binary (two-digit) system. The internal memory was 1000 words.

1957-1965, Second Generation Computer; used transistors; became cheaper, faster, more reliable; many universities, businesses, and government agencies could afford computers.

1957, FORTRAN compiler, the first high-level programming language, was released.

1965-1975, Third Generation Computer; used integrated circuits with transistors, resistors, and capacitors etched onto a piece of silicon; still reduced the size and price, adding to a general trend in the computer industry of miniaturization.

1975-1985, Fourth Generation Computer; creation of microprocessors, such as the Intel 4004, still decreased size and cost and increased speed and reliability of computers; these were called microcomputers. In 1981, Microsoft Disk Operating System (MS-DOS) was released to run on the Intel 8086, leading to Microsoft Windows 1.0 released in 1985.

1985 to Present day, Fifth Generation Computer; changes that occurred are plenty, witnessed home computers and personal computer (PC's) and more; with the evolution of the Internet, personal computers are becoming as common as the television and telephone in the household.

Timeline of Communication technology

The telephone is one of the most marvelous inventions of the communications era; the physical distance is conquered instantly.

- any telephone in the world can be reached through a vast communication network that spans oceans and continents.*
- the form of communication is natural, namely human speech.*

Advances in communication technologies have led to increased worldwide connectivity while new technology like cell-phone has increased mobility.

Communication is no more just two persons talking, it is much more.

- human communicate with a knowledge source to gather facts ,*
- human communicate with an intelligent systems for solving problems requiring higher mental process,*
- human communicate with experts to seek specialized opinion,*
- human communicate with logic machines to seek guidance,*
- human communicate with reasoning systems to get new knowledge, and*
- human communicate for many more things to do.*

Modern digital communications

In 1947, Shannon created a mathematical theory, which formed the basis for modern digital communications. Since then the developments were :

1960s, three geosynchronous communication satellites, launched by NASA.

1961, packet switching theory, was published by Leonard Kleinrock at MIT.

1965, wide-area computer network, a low speed dial-up telephone line, created by Lawrence Roberts and Thomas Merrill.

Within this network, a time-sharing computer could dial into another computer and remotely run programs on that system.

1966, Optical fiber was used for transmission of telephone signals.

Late 1966, Roberts went to DARPA to develop the computer network concept and planned for the "Advanced Research Projects Agency Network - ARPANET", which he presented in a conference in 1967. There Paul Baran and others at RAND presented a paper on packet switching networks for secure voice communication in military use. The observations and the outcome of this 1967 conference were :

The work at MIT (1961-1967), at RAND (1962-1965), and at NPL (1964-1967) had all proceeded in parallel without any of the researchers knowing about the other's work. The word "packet" was adopted and the proposed line speed was upgraded from 2.4 kbps to 50 kbps to be used in the ARPANET design."

1968, DARPA for ARPANET, released RFQ for development of Interface Message Processors (IMP's) called packet switches.

Bolt Beranek and Newman (BBN) won the contract, selected a Honeywell minicomputer as the base to build the switch (IMP). The implementation responsibilities of the overall ARPANET were assumed by one or more individual : Architectural design - by Bob Kahn; Network topology design and optimization - by Roberts with Howard Frank and his team at Network Analysis Corporation; Data networking technology and network measurement system preparation by Kleinrock's team at University of California, Los Angeles (UCLA).

Internet Era

The year 1969, saw the beginning of the **Internet era**, the development of **ARPANET**, an unprecedented integration of capabilities of telegraph, telephone, radio, television, satellite, Optical fiber and computer.

University of California, Los Angeles (UCLA) became the **first node** to join the ARPANET. That meant, the UCLA team connected the first switch the Interface Message Processors (IMP) to the first host computer (a Honeywell minicomputer). Bits began moving between the UCLA computer and the IMP. Next day, they had messages moving between the machines. Thus, **ARPANET was born**.

By then Crocker finished the initial ARPANET Host-to-Host protocol, called Network Control Protocol, NCP.

A month later the **second node** was added at Stanford Research Institute (SRI) and the first Host-to-Host message on the Internet was launched from UCLA. It worked in a **cleaver way**, means :

- ‡ Programmers for "logon" to the SRI Host from the UCLA Host - typed in "log" and the system at SRI added "in" thus creating the word "**login**".
- ‡ Programmers could communicate by voice as the message was transmitted using telephone headsets at both ends.
- ‡ Programmers at the UCLA end typed in the " I " and asked SRI if they received it; came the voice reply "**got the I**".

By 1969, **four nodes** (UCLA, SRI, UC SANTA BARBARA, and University of Utah). UCLA served for many years as the ARPANET Measurement Center.

In mid-1970's, UCLA controlled a **geosynchronous satellite** by sending messages through ARPANET from California to East Coast satellite dish.

By 1970, they connected **ten node**.

Bolt Beranek and Newman (BBN) designed the Interface Message Processors (IMP's) to accommodate 64 computers and only one network.

In 1972, INWG, the International Network Working Group, was formed to further explore packet switching concepts and internetworking.

Kahan at DARPA introduced the idea of open-architecture networking. Cerf and Kahn developed an internetworking concept (CATENET) to connect networks, that use different packet types and transmission rates such as a satellite and radio network, with gateways (routers).

In 1973, TCP/IP, the Transmission Control Protocol/Internet Protocol, Kahn developed, to meet the needs of open-architecture network environment.

ARPANET Host-to-Host Network Control Protocol (NCP) remained to act like a device driver, while the new protocol (TCP/IP) would be more like a communications protocol. The idea was to connect a number of different networks designed by different vendors into a network of networks (the "Internet") and deliver a few basic services that everyone needs (file transfer, electronic mail, remote logon) across a very large number of client and server systems.

Note : TCP/IP is named after two of the most important protocols in it.

- ‡ IP is responsible for moving packet of data from node to node.*
- ‡ TCP is responsible for verifying delivery of data from client to server.*
- ‡ Sockets are subroutines that provide access to TCP/IP on most systems.*

In 1976, X.25 protocol was developed for public packet networking.

The X.25 is a standard network protocol adopted by the Consultative Committee for International Telegraph and Telephone (CCITT). It allows computers on different public networks to communicate through an intermediary computer at the network layer level.

In 1977, first internet work was demonstrated by Cerf and Kahn. They connected three networks with TCP : 1. Radio network, 2. Satellite network (SATNET), and 3. Advanced Research Projects Agency Network (ARPANET).

*In 1980's, the ARPANET was evolved into the **INTERNET**. Internet is defined officially as networks using TCP/IP.*

On January 1, 1983, the ARPANET and every other networks attached to the ARPANET officially adopted the TCP/IP networking protocol.

All networks that use TCP/IP are collectively known as the Internet. The standardization of TCP/IP allowed the number of Internet sites and users to grow exponentially.

*Today, **Internet** has millions of computers and hundreds of thousands of networks. The network traffic is dominated by its ability to promote "**people- to-people**" interaction.*

Timeline of AI Events

The concept of AI, Artificial Intelligence, as a true scientific pursuit is a very young. Most researchers agree the beginning of AI with Alan Turing.

*1950, Turing test, by Alan Turing, in the paper "Computing Machinery and Intelligence" **measured machine intelligence.***

This test called for a human judge to use a computer terminal to interact with human as well as with the machine; if the judge cannot reliably tell which is human and which is machine, then the machine is said to pass the test and the machine would be considered intelligent.

*1950, Intelligent behavior, Norbert Wiener, observed **link between human intelligence and machines**, and theorized intelligent behavior.*

*1955, Logic Theorist, a program by Allen Newell and Herbert Simon, claimed that **machines can contain minds** just as human bodies do, proved 38 out of the first 52 theorems in Principia Mathematica.*

*1956, **Birth of AI**, Dartmouth Summer Research Conference on Artificial Intelligence, organized by John McCarthy, regarded as the father of AI.*

*This conference was essentially an extended brain-storming session lasted a month, to draw the talent and expertise of others interested in machine intelligence. **The term artificial intelligence was first coined.** The Dartmouth conference served to lay the groundwork for the future of AI research and discussed computers, natural language processing, neural networks, theory of computation, abstraction and creativity, all still open research areas.*

1957, General Problem Solver (GPS), was tested. The GPS was an extension of Wiener's feedback principle, and was capable of solving to a greater extent the common sense problems.

1958, LISP language, was invented by McCarthy and soon adopted as the language of choice among most AI developers.

1963, DoD's Advanced Research projects started at MIT, researching Machine-Aided Cognition (artificial intelligence), by drawing computer scientists from around the world.

1963, Re-examined ideas formed at the 1956 Dartmouth conference.

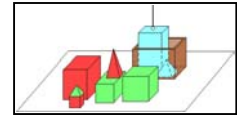
AI began to pick up momentum, the field was still undefined.

The centers for AI research began forming at Carnegie Mellon and MIT, and new challenges were faced : creating systems that could efficiently solve problems, such as the Logic Theorist and making systems that could learn by themselves.

1968, Micro-world program SHRDLU, at MIT, controlled a robot arm operated above flat surface scattered with play blocks.

SHRDLU could plan, carry on simple conversations typed in

natural English, like "stack up both of the red blocks and either a green cube or a pyramid".



Mid-1970's, Expert systems, for Medical diagnosis (Mycin), Chemical data analysis (Dendral) and Mineral exploration (Prospector) were developed.

Expert system is an intelligent computer program, uses knowledge and inference procedure to solve problems difficult enough and require significant human expertise for their solution. A typical expert system includes : user interface, working memory, knowledge base, inference engine, and explanation system.

During 1970's, Computer vision (CV) technology, machines that "see" emerged. David Marr was first to model the functions of visual system.

Purpose of CV is to program a **computer to "understand"** a scene or features in an image; It is a combination of concepts, techniques and ideas from Digital Image Processing, Pattern Recognition, Artificial Intelligence, and Computer Graphics.

1972, Prolog, a logic programming language by Alain Colmerauer.

Backwards reasoning theorem prover applied to declarative sentences in the form of implications, e.g., : If B1 and B2 . . . and Bn then H.

Transition from Lab to Life

During the 1980's, AI was moving at a faster pace into the corporate sector. Another fields of AI, the machine vision, made there way into marketplace.

1986, US sales of AI-related hardware and software surged to \$425 million; high demand for expert system because of their efficiency.

AI put to the Test

Desert Storm: the first information war 17 January – 28 February 1991.

► **Artificial Intelligence**

John McCharthy, who coined the term in 1956, defined AI as "the science and engineering of making intelligent machines.

Intelligence relate to tasks involving higher mental processes; e.g., solving problems, representation of knowledge, recognition and classification of patterns, learning through induction, deduction, and building analogies, optimization, language processing, and many more.

Intelligent behavior is depicted by perceiving, acting in complex environments, learning and understanding from experience, reasoning to solve problems and discover hidden knowledge, applying knowledge successfully in new situations, thinking abstractly, using analogies, communicating with others, and more.

Goals of AI : Science based is to develop concepts, mechanisms and understand biological intelligent behavior. The emphasis is on understanding intelligent behavior. Engineering based goal of AI is to develop concepts, theory and practice of building intelligent machines. The emphasis is on system building.

AI Approaches depicts four possible goals to pursue. The approaches followed are defined by choosing goals.

1. **Think like human** : Cognitive science approach; effort to make computers think; machines with minds
2. **Think Rationally** : Laws of thought approach; computations that make it possible to perceive, reason, and act; inference mechanisms that are provably correct and guarantee an optimal solution; formalize the reasoning process, a system of logical rules and procedures for inference.
3. **Act like human** : Turing Test approach; perform functions requiring intelligence when performed by people; how to make computers do things which at the moment people do better.
4. **Act Rationally** : Rational agent; explain and emulate intelligent behavior in terms of computational processes; automation of intelligence; act sufficiently if not optimally in all situations

Hard or Strong AI aims to build machines that can replicate human intelligence completely.

Soft or Weak AI accomplish specific problem solving or reasoning tasks that do not encompass the full range of human cognitive abilities.

Knowledge is a collection of **facts**. To manipulate these facts by a program, a suitable representation is required. A good representation facilitates problem solving.

Reasoning is the act of deriving a conclusion from certain premises using a given methodology; a system of logical rules and procedures for **inference**.

Learning denotes changes in the system that are adaptive, means enables the system to do the same task(s) more efficiently next time; **programs learn** from what the facts or behaviors can represent.

Expert system is a model and associated procedure that exhibits, within a specific domain, a degree of **machine expertise** in problem solving that is comparable to that of a human expert.

Commonsense is ability to analyze a situation based on its context, using millions of integrated pieces of **common knowledge**;

Everyone knows that dropping a glass of water, the glass will break and water will spill on podium. However, this information is not obtained by formula or equation for a falling body or equations governing fluid flow.

AI Techniques depicts how we represent, manipulate and reason with knowledge in order to solve problems.

Applications of AI : problem solving, search and control strategies, speech recognition, natural language understanding, computer vision, expert systems.

New Generation of AI

Soft Computing, a new multidisciplinary field, to construct new generation of Artificial Intelligence, known as **Computational Intelligence**;

Definitions : Lotfi A. Zadeh, 1992 : "Soft Computing is an emerging approach to computing which parallel the remarkable ability of the human mind to reason and learn in a environment of uncertainty and imprecision".

The Soft Computing consists of several computing paradigms mainly : **Fuzzy Systems, Neural Networks, and Genetic Algorithms.**

- Fuzzy set : fuzzy knowledge representation via fuzzy membership function; real world knowledge is vague, imprecise, uncertain, ambiguous, inexact, or probabilistic in nature.
- Neural Networks : learning and adaptation inspired by biological system; mimic certain processing capabilities of the human brain; Back-Propagation Network in a situations where data is incomplete or noisy, Associative memory for content addressability and Adaptive Resonance Theory to resolve plasticity-stability dilemma;
- Genetic Algorithms : evolutionary computation; mimic some processes observed in natural evolution, a combination of selection, recombination and mutation; survival of the fittest.
- Hybrid systems : integration of neural network, fuzzy logic & genetic algorithm; Neuro-Fuzzy, Neuro-Genetic, and Fuzzy-Genetic systems.

Intelligent machines tolerant of approximation, uncertainty, imprecision, and partial truth to achieve close resemblance with human like decision making; provide solutions to real world problems, which are not modeled, or too difficult to model mathematically.

Perspectives on AI : Myth and Speculation

AI research was founded at a conference on the campus of Dartmouth college in the summer of 1956. John McCarthy, Marvin Minsky, Allen Newell, Herbert Simon and others attained and became the leaders of AI research for many decades. They and their students wrote programs that were astonishing : *computers were solving word problems in algebra, proving logical theorems and speaking English.* By the mid 60s, their research was heavily funded by U.S. Department of Defense. They were optimistic about the future of the new field.

*In 1965, Herbert Simon, **promised** that by 1985 "machines will be capable of doing any work that a man can do."*

*In 1967, Marvin Minsky, **proclaimed** "within a generation the problem of creating 'artificial intelligence' will be substantially solved";*

*By 1970s, AI was **running into trouble**. Nobody could come close to making a computer understand the sentences in a simple children's story with the comprehension of a four-year-old.*

*By 1980s, A host of **industrial applications emerged**; a few succeeded, to distinguish between objects in front of them, but most did not.*

*In 1989 the **Pentagon dropped a project** to build a "smart truck" that could operate on its own on a battlefield.*

*In 1997, IBM's Deep Blue **computer beat Carry Kasparov** in a chess match, but most people viewed this achievement as simply a demonstration that the game could be reduced to a mass of complex calculations.*

Machine-Human Intelligence Interface : "Professor Cyborg".

Professor Kevin Warwick at the University of Reading, author of the book "March of the Machines: Why the New Race of Robots Will Rule the World", performing a series of controversial experiments :

- **Robot learning experiment** across the internet; One robot with an ANN brain learnt how to move around then taught via the internet another robot to behave in the same way. In future robots will not need human programming, but will reprogram and rebuild themselves;

- **Project Cyborg** : a combination of cybernetic and organism.

Warwick's first experiment in 1998 was a chip implant in his arm to send radio signals to computer controlled devices in close proximity : could open door, manipulate lights, have a computer say 'hello', and adjust temperature of a room. The purpose was to determine the exact level of signal strength the implant could emit and how well the implant could be tolerated by the body. Warwick's second experiment in 2002, sending signals directly from his nervous system to various objects, and other humans. He used a chip to control a robotic arm, that could mimic the movements of his own arm. Later, his wife joined in the experiment by having an electrode array implanted and interfaced with her own nervous system. The goal was to send their feelings back and forth for comparison, and see if some type of telepathic communication could be achieved. The experiment was successful at sending signals, but not strong enough to be felt by the other person to any significant degree, may be the raw noise data their nervous systems receiving were damaging enough to make them lose their mind.

Warwick's other experiments to :

- determine if humans can enhance their senses with computer chips;
- could an implant allow us to see infrared light?
- could feelings and brain patterns be uploaded to a computer ?

AI in Early 21st Century

In the 1990s and early 21st century, AI achieved its greatest successes in

- Logistics management, Data mining, Medical diagnosis;*
- Reading machines for the blind, speech-recognition devices;*
- Computers that detect financial fraud by noticing irregular behavior;*
- Automate manufacturing, responding to changes in supply and demand.*

Military made good use of early AI , spending millions on research;

- Robots that can walk like animals, can perform reconnaissance missions without the risk a human's life.*
- Intelligent computers can fly airplanes and missiles, make choices based on the situation it is presented with.*

Autonomous AI agents

- In 1999, NASA AI agent ran a satellite beyond Mars for over a day, without ground control. The agent continually reviewed and updated the mission goals according to the satellite's functioning hardware. Earthlings could subscribe to a mailing list and get frequent bulletins from the satellite about what it was currently thinking about.*
- Buyer agents or shopping bots, travel around a network (internet) retrieving information about goods and services, for commodity products such as CDs, books, electronic components, and other one-size-fits-all products. Amazon.com and eBay are good example of a shopping bot. This technology is known as collaborative filtering.*

Technological Singularity

The term "singularity" is used in many disciplines to refer to the occurrence of a major event. From a technology perspective, it refers to a point in the future where *computers advance so much that people no longer are the source of great invention; machines will be responsible for creating the most important, new breakthroughs with minimal, or without, human input.* The idea of Singularity was introduced by Vernor Vinge in 1993.

- **"The Coming Technological Singularity : How to Survive in the Post-Human Era"** by Vernor Vinge (1993) at the VISION-21 Symposium sponsored by NASA and the Ohio Aerospace Institute.

Within thirty years, we will have the technological means to create superhuman intelligence. Shortly after, the human era will be ended. Is such progress avoidable? If not to be avoided, can events be guided so that we may survive? These question are investigated. Some possible answers (and some further dangers) were presented in symposium.

- **"The Law of Accelerating Returns"** by Ray Kurzweil (2001) : An analysis of the history of technology shows that technological change is exponential, contrary to the common-sense "intuitive linear" view.

We won't experience 100 years of progress in the 21st century. It will be more like 20,000 years of progress (at today's rate).

Recall, the first technological steps - sharp edges, fire, the wheel etc., took tens of thousands of years. By 1000 A.D., progress was much faster. The 19th century, saw more technological change than in the nine centuries preceding it. In 20th century, the first 20 years we saw more advancement than in whole of the 19th century. The technological progress in the 21st century will be of the order of 200 centuries. In contrast, the 20th century saw only about 25 years of progress (at today's rate of progress) since we have been speeding up to current rates. The 21st century will see a 1000 times greater technological change than its predecessor. Kurzweil organized these observations into what is called the law of accelerating returns.

Intelligent Machine-Human Society

The 21st century, year 2009, we are surrounded by technology. In 10 years we have gone from personal stereos, to iPods and tiny mp3 players; from floppy drives, to CDs, to DVDs and USB sticks and SD cards that can hold libraries of information. Technology changes too fast; what we see in the marketplace this year is primitive in comparison to the technologies being tested and designed right now.

AI for long time a theme of science fiction novels are seen in practice.

- You step onto a commercial flight, there is a **computer controlling the airplane 90% of the time**. Computers can even land the airplane should a pilot choose not to.
- A **robot vacuum cleaner** not only cleans floor each day, it works out where walls and doors are in house, it knows where its home is and when the battery is low it hooks itself up to the charger. You come home at night you always find a dust free floor.
- **AI Pets behave like real animals and Baby dolls are almost lifelike;**
I-Cybie Robot Dog, features are over a hundred actions, voice recognition technology to learn the owner's voice, responds to sounds, wall/obstacle detection prevents running into objects, edge detection senses table edges that prevents falling down, motion detection, orientation sensors allow to stand up after falling, sound sensors to find the location of a sound source, touch sensors to detect being petted.
Baby dolls are almost life like, need caring for. Dolls now move, talk, react to noise, heat and movement. They do nearly everything a real baby does. The skin is even lifelike.

In very near future

The AI technology will not only drive the world but will almost control it.

- Imagine, technology produces amazing **artificial red blood cells** built of nanotechnology that will let you hold your breath for four hours. This is an actual application that has been proposed. It would be pretty respectable, because it means that you could have a heart attack and walk to the doctor.*
- NASA and Silicon Valley companies like Google are designing everything from next-generation search engines to **machines that listen or that are capable of walking around in the world.***
- Imagine a world where **we walk side by side with machines. Machines that can converse, think, make choices and react.** Machines so lifelike you can't tell the difference. This is not Star Trek or Star Wars; this is future reality.*

"Scientists Worry Machines May Outsmart Man", John Markoff, The New York Times, July 25, 2009. Impressed and alarmed by advances in artificial intelligence, a group of computer scientists is debating whether there should be limits on research that might lead to loss of human control over computer-based systems that carry a growing share of society's workload. .

Conclusion

We live in an era of rapid change moving towards a network society of machines that has the information and knowledge. We require seamless, easy-to-use, high quality, affordable communications between people and machines, anywhere, and anytime. The creation of intelligence in machine has been a long cherished desire to replicate the functionality of the human mind. Intelligent information and communications technology (IICT), emulates and employ some aspect of human intelligence in performing a task. The IICT based systems, include sensors, computers, knowledge-based software, human-machine interfaces and other devices. The IICT enabled machines and devices anticipate requirements and deal with environments that are complex, unknown, unpredictable and bring the power of computing technology into our daily lives and business practices. Intelligent systems were first developed for use in traditional industries, such as manufacturing, mining, and more, enabling the automation of routine or dangerous tasks to improve productivity and quality. Today, intelligent systems applications exists virtually in all sectors where they deliver social as well as economic benefits. This talk is prepared, using information available from open sources, mainly internet sources, for bringing general awareness about Intelligent Machine-Human Communication Interfaces leading to Intelligent Machine-Human Society.

References : Open sources – mainly internet.

Note : This talk is prepared, using information available from open sources, mainly internet, for bringing general awareness about Intelligent Machine-Human Communication Interfaces leading to Intelligent Machine-Human Society.