AI: Background, History and Future Opportunities

Raj Reddy
Carnegie Mellon University
Pittsburgh, PA 15213

Hype and Misinformation About AI

- Lot of Hype and Misinformation
- Incorrect Mistaken Assumptions
  - AI will NOT Replace Humans
  - AI will NOT Kill Us
  - AI will NOT Enslave Us
  - AI will Lead to Loss of Some Jobs
    - But More New Jobs will Ultimately be Created

Background and History

What is AI?

- AI is an attempt to automate tasks that are usually thought to be uniquely Human Requiring Intelligence, Intuition, Creativity, Innovation, Emotion, Empathy
- Early Attempts: prove theorems, play chess, solve puzzles
- Later Systems attempted Speech Understanding, Image Understanding, Music Understanding, Painting, Stock Market, etc.
- Usually leads to Imperfect Solutions
  - Usually Human coding using Heuristics, Rules, and
  - Statistical Models - HMMs
  - Non Sequential Algorithms
- AI Principles: Use of Knowledge to Solve Problems
  - Search Compensates for Lack of Knowledge
  - Knowledge Compensates for Lack of Search

Major Breakthroughs in AI of the 20th Century

- Enabled by Brute-force, Heuristics, Human Coding of Rules and Knowledge, and Simple Machine Learning (Pattern Recognition)
  - World Champion Chess Machine
    - IBM Deep Blue
  - Mathematical Discovery
    - Proof Checkers
  - Accident Avoiding Car
    - CMU: No Hands Across America
  - Robotics
    - Manufacturing Automation
    - Disaster Rescue Robots
  - Speech Recognition Systems
    - Dictation Machine
  - Computer Vision and Image Processing
    - Medical Image Processing
  - Expert Systems
    - Rule Based Systems
    - Knowledge Based Systems

AI in 21st Century

- Paradigm Shift in Science
  - First 3 Paradigms: Experiment, Theory, Simulation
    - Rutherford, Bohr, Oppenheimer
  - 4th Paradigm: Data Driven Science
- Create Next Generation AI systems
  - Data Driven AI systems
  - To Solve Previously Unsolved Problems
- Recent Breakthroughs Enabled by Big Data and Machine Learning
  - Language Translation
    - Google Translate: Any Language to Any Language
  - Speech to Speech Dialog
    - Siri, Cortana, Alexa
  - Autonomous Vehicles
    - CMU, Stanford, Google, Tesla
  - Deep Question Answering
    - IBM's Watson
  - Robo Soccer
  - World Champion Poker
    - CMU Libratus
      - No Limit Texas Hold'em Poker

Near Term Societal Impact of AI

- Existing AI Technology Can be Used to Empower the 3 Billion People at The Bottom of the Pyramid
  - 3 Billion People with Incomes of less than $3 a day
- Most of Them Are Also Semi-literate, i.e., Cannot Read, Write and/or Understand Any Language
  - Cannot use Keyboard or Touch based Computing Apps
- Only Acceptable Mode of Communication is Speech
  - Voice Computing a la Amazon Echo is the Key
- Personal Assistants that Require Only Speech based Interaction
  - Voice Computing (No Keyboard or Touch) Can Help The Semi-literate to Read Newspapers, Watch Foreign Language Movies, Listen to Khan Academy Lectures, Vote Online and Order Groceries Online

Speech to Speech Multi-Lingual Translation for the Semi-literate

- An Intelligent Agent That Anticipates What You Want To Do And Helps You To Do It Using Local Language and Clarification Dialog
  - Entertainment and Education: Streaming Video Translation
    - Alexa play Hamlet (BBC Shakespeare)
  - Reading Newspapers: Text to Speech Translation and/or Synthesis
    - Alexa read China Daily
  - Buying and Selling: Voice Dialog Management
    - Alexa order usual brand Rice, Meat and Vegetables
  - Communication: Voice and/or Video Email, Chat
    - Alexa call my Grandson in Shanghai
  - Banking: Monitor Bank account, Pay Bills
    - Alexa charge my mobile device with 1000 rupees
  - Online Voting
    - Voice Dialog to enable the Authorization, Authentication and Audit
- All Such Apps Will Require Speech Recognition, Spoken Dialog, and Speech to Speech Translation
  - (No Keyboard or Touch)
  - Microsoft Demonstrated Speech to Speech translation in 2012

AI: Future Opportunities

AI : Near term Future (2 to 3 Years)

Cognition Amplifiers That Enhance Human Capabilities

Do Tasks Faster and with Less Effort

Cognition Amplifiers in Service of Society

- A Cognition Amplifier (COG) is an Intelligent Agent that anticipates what you want to do and helps you to do it
  - Cognition Amplifiers Enhance Human Capabilities
    - Do Tasks Faster and with Less Effort
- A Cognition Amplifier (COG) is a
  - Personal
  - Enduring
  - Autonomic Intelligent Agent that
  - Anticipates what you want to do and does it
- Always On, Always Working, Always Learning

Examples of COGs in Service of Society

- COGs personalized and mass customized agents as part of Knowledge as a Service (KaaS) may be Used by Everyone on the Planet for tasks such as
  - Buying and selling: Transact with multiple providers
  - Email: Filter spam, understand and respond to actionable email
  - News: Based on topic preferences, novelty, collaborative filtering
  - Banking: Monitor bank account, Credit Cards, Pay Bills
  - Travel: Flights, hotel, schedule disruptions, cancellations
- Each Person May Have Thousands of Cogs as Personal Assistants

AI: Longer Term Future (5 to 10 Years)

Guardian Angels That Enable Humans to Do Tasks They Cannot Do Today.

Super-Human AI?

Guardian Angels in Service of Society

- Discover and Warn Humans About Unanticipated Events Impacting Safety, Security, and Happiness
- Guardian Angels Enable Humans to Do Tasks They Cannot Now Do.
  - Super-Human AI?
- A Guardian Angel (GAT) is a
  - Personal
  - Enduring
  - Autonomic
  - Intelligent Agent
- Always On, Always Working, Always Learning

GATs in Service of Society

- GATs are personalized and mass customized agents as part of KaaS for
  - Just-in-Time Warnings: Hurricanes, Earthquakes, Extreme Weather
  - Act as Coach in Health and Education Matters
  - Accident Alerts and Rerouting; Transport Strikes
  - Scarcity of Essential Resources: Food, Energy, Water etc.
- Assume Everyone on the Planet has Personalized Guardian Angels (GATs)

Architecture of Intelligent Agents

Steps in Creating Smart X

- Smart X: Water Security, Food Security, etc.
  - Guardian Angel Apps Dedicated to each Task for each Person
- To Create COGs and GATs in Service of Society We Need (Big) Data from Every Person on The Planet
  - Time, Location (GPS), Accelerometers, Barometers, Microphones and Cameras
  - GigaBytes Per Person Every Day
- Monitor, Diagnose, and Repair Cycle For Each Human Need
  - Activity Monitoring enables
  - Discovery of Intention which enables
  - Cognition Amplifiers (COGs) and Guardian Angels (GATs)

Technologies of Guardian Angelss

Guardian Angelss Publish and Subscribe

- Service Agents are created by service providers using agent templates included in the platform
  - Download and Pay just as for Apps and Personalization
- Guardian Angels Can request and manage services on behalf of their Wards.
- Every organization that wants to enable access to their services by Guardian Angels will create a Service Agent for this purpose.
- Opt-in “Waze” like Models
- Privacy
  - Individual
  - Other participants
- Legal
  - Can be subpoena-ed
- Security
  - Information falling into wrong hands

Architecture of Guardian Angelss

Guardian Angelss Publish and Subscribe

- Guardian Angelss are Mobile Apps that can be enabled for Any Person on the Planet
  - Unlike APPs of today, Guardian Angelss are Mass-customized to Each Individual
  - Designed to be Non-intrusive, Autonomic, and Device Independent
  - Always On, Always Present and Always Working
  - Always Learning
    - Enduring (life-long)
- Guardian Angelss Monitor, Analyze and Learn From Experience;
  - Learn From Own Experience And Experience of Others
    - And share knowledge with a community of Guardian Angelss
  - Automated Discovery of Data and Information Sources
- Guardian Angelss Publish and Subscribe Anonymized Data of User Activities and Experiences
- Data, suitably anonymized, can be used to learn appropriate responses for every possible situation by
  - Learning preferences by observing user choices,
  - Learning by task similarity and user similarity,
  - Learning by error correction and
  - Simply learning thru clarification dialog (does that mean yes? Would you care to define it?)

Personalization and Customization of Guardian Angels

Cloud Based Guardian Angel Platform Linked to User Smart Phone

Learning

- Learn by Watching
- Learn by being taught
- Learn by doing
- Learn by asking others
- Learn by discovery

Security

- Multimodal authentication
- Continuous authentication
- Encryption

Big Data Management

- Process, index, story and retrieve data
- Mine, Cluster, and Summarize relevant experience

Dialog

- With humans
- With other agents

Self Healing

- Detect errors
- Resolve errors

Power Mgmt

Activity Monitoring

Multi-Sensor Integration

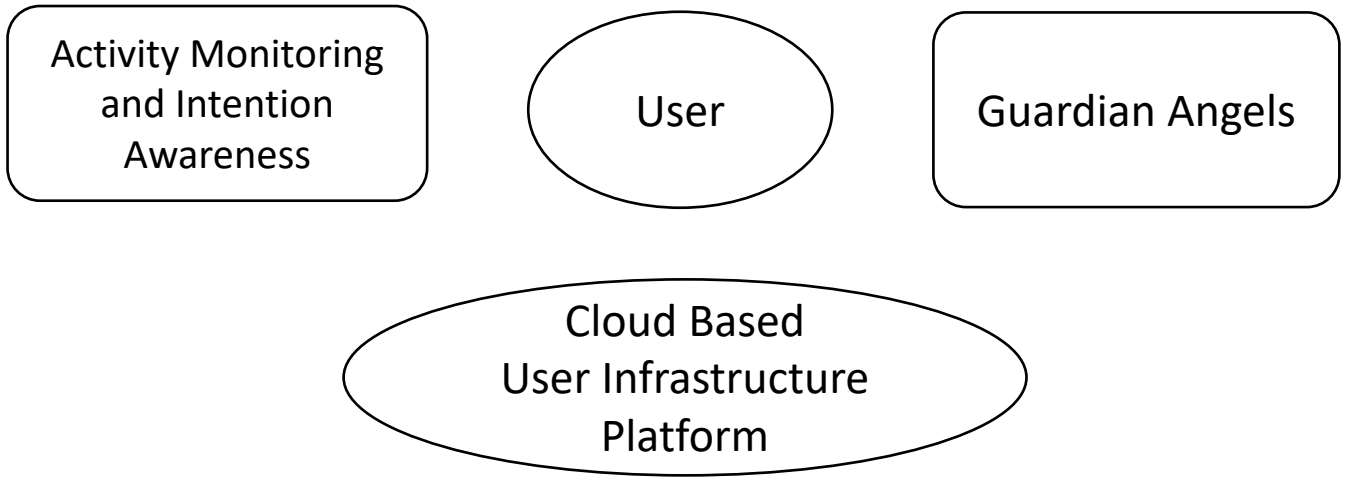
Autonomic Systems

Etc.

Family of Personalized Guardian Angels

Subscribe to Local, National and Global Sources and Act on Relevant Information

Publish/Subscribe Eco System of Guardian Angel Global Infrastructure Platform



Knowledge Source Publishers

Global, National and Local

Knowledge Source Distributors

ReTweet Model

Global DataBase of Humankind

Guardian Angel Market Place

Necessary Conditions for Success in Development of COGs and GATs

- Infrastructure
- Instrument Data Sources
  - People
  - Places and
  - Things
- Computing Power: Processor, Memory and Bandwidth
  - Multi Farm Cloud Computing
  - Super Computers for Processing
  - Zettabyte (10^{21} Bytes) Storage Farms
  - Million Gigabit bandwidth
- Machine Learning and Analytics

Challenge: How To Provide A Guardian Angel To Every Man, Woman And Child?

- By 2020, Everyone on The Planet Has Access to a Phone with Global Connectivity
  - A Phone is Expected to Cost $50
- Every Man, Woman And Child will have Access to 16GB+ of Space on The Cloud from Facebook, Google And Microsoft
- Everyone on The Planet Has Access to
  - Unlimited Computation, Memory and Bandwidth
- Language divide and literacy divide limits access to the internet-enabled solutions to many people in the world.
  - Providing the right information in the right language and right medium enables scalability to all the people on the planet.
- Sustainability and Affordability are natural consequences of exponential reduction in size and cost of Information Technology.

Potential Economic Impact of AI 2.0

Emergence of Knowledge as a Service (KaaS) Industry

- Every person on the planet will be able to perform many daily habits more effectively using Guardian Angelss
  - Daily habits (routines, activities) include a wide spectrum from routine tasks (such as banking and travel planning) to tasks too difficult for the user
- Over 80% of all human activity will done by Guardian Angelss by 2020
- 7 Billion People Market Vs 2 Billion Today
- Ultimately Humans Could be 10 Times More Efficient and Effective
- Global GDP is $100 Trillion
- Even 10% improvement will lead to $10T additional wealth creation

In Conclusion…

- Many of the AI Tasks We are Working on were Started 6 Decades Ago.
  - Progress Has Been Slow and Problematic
  - Even Deep Learning Started 35 Years ago
    - Geoff Hinton Invented the Backprop Algorithm at CMU 1985
- AI Research will Continue to Make Incremental Progress on All the Tasks from the Past.
  - Industry on New Applications of Image Processing, Speech and Robotics
  - Research Labs on Previously Unexplored Tasks such as Anger, Pain and Humor
- The Main Difference is that, We Now Have A Million Times More Computing Power, Million Times Memory and Million Times Bandwidth!
- As McCarthy said in 1980s, We May Need 1.7 Einsteins, 3 Maxwells and Funding of the magnitude of the 0.7 Manhattan Project to get to Human Level AI
- There is No Danger of AI Taking Over the World ☺