Natural Language Based Intelligent Robot to Advance Industrial Automation and Digital Manufacturing

Keynote Speech

World Convention on Robots, Autonomous Vehicles and Deep Learning, Sept 10-11, 2018, Singapore.

Emdad Khan

Dept. of CS
Maharishi U. of Management (MUM)
Iowa, USA
ekhan@mum.edu

InternetSpeech, Inc
San Jose, CA
USA
emdad@internetspeech.com

Topic

- Automation & Its Impact
- Progression of Automation – Industrial to Mass Production to Digital to…..
- The need for Intelligent Agent based Robot / Softbot with Huma-like Intelligence!
- Need for Natural Language Computing (NLC) - best natural user Interface with any computing device; almost essential with small devices like IOT.
- Applications of AI, ML, NLP, Knowledge / Experience & Cognition based Intelligent Bots.

Some State of the Art Robots/Softbots

- Three Impressive 2018 Human Like Robots:

  http://www.hansonrobotics.com/robot/sophia/

- Some Robots for Industrial Automation & Digital Manufacturing



A 2D vision guided robot performs bolt shooting and tightening on automotive underbody. *(Courtesy of Recognition Robotics Inc.)*



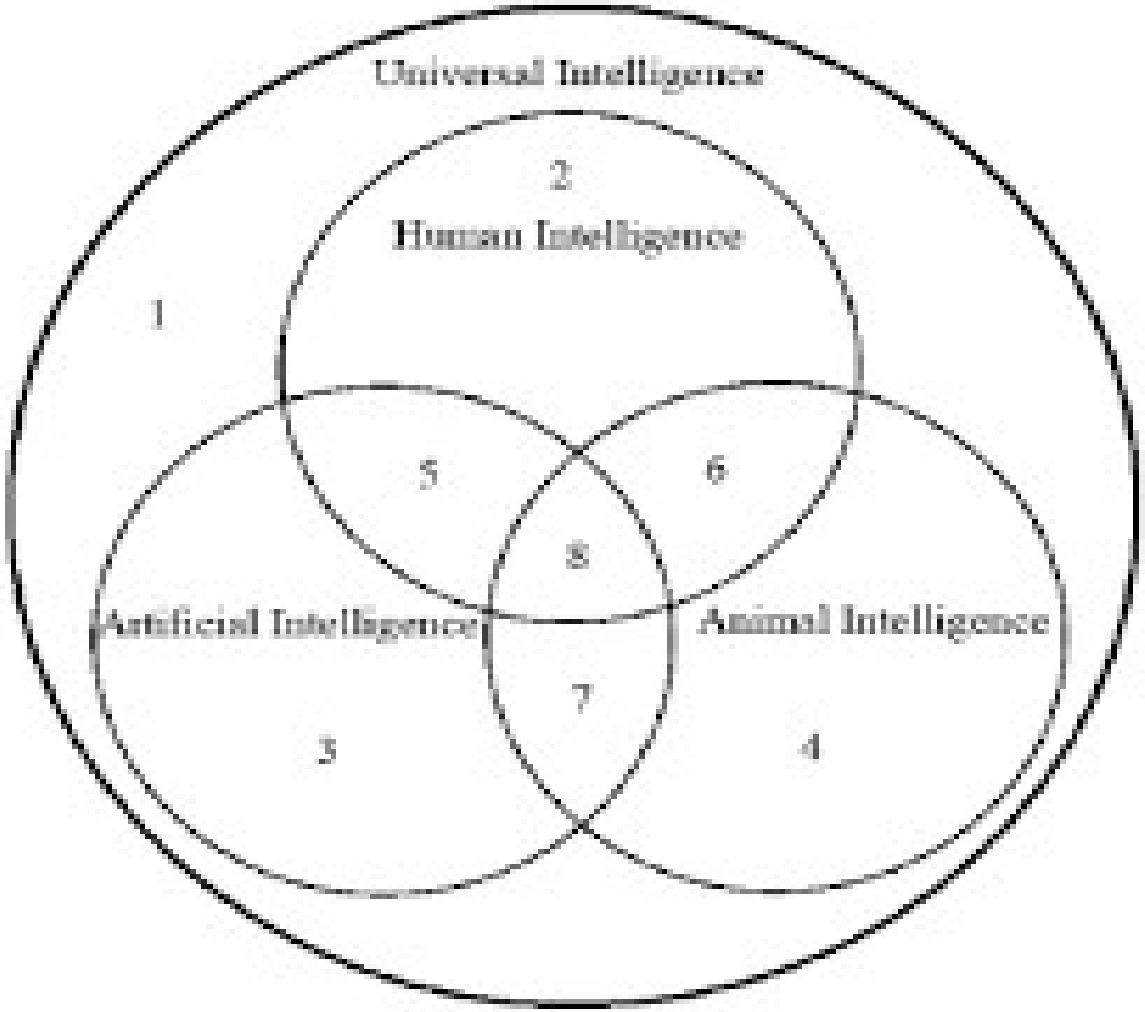
Robot picks and stacks randomly piled parts in six degrees of freedom without calibration, CAD files, lasers or point clouds. *(Courtesy of Recognition Robotics Inc.)*

Major Challenges (and Opportunities!)

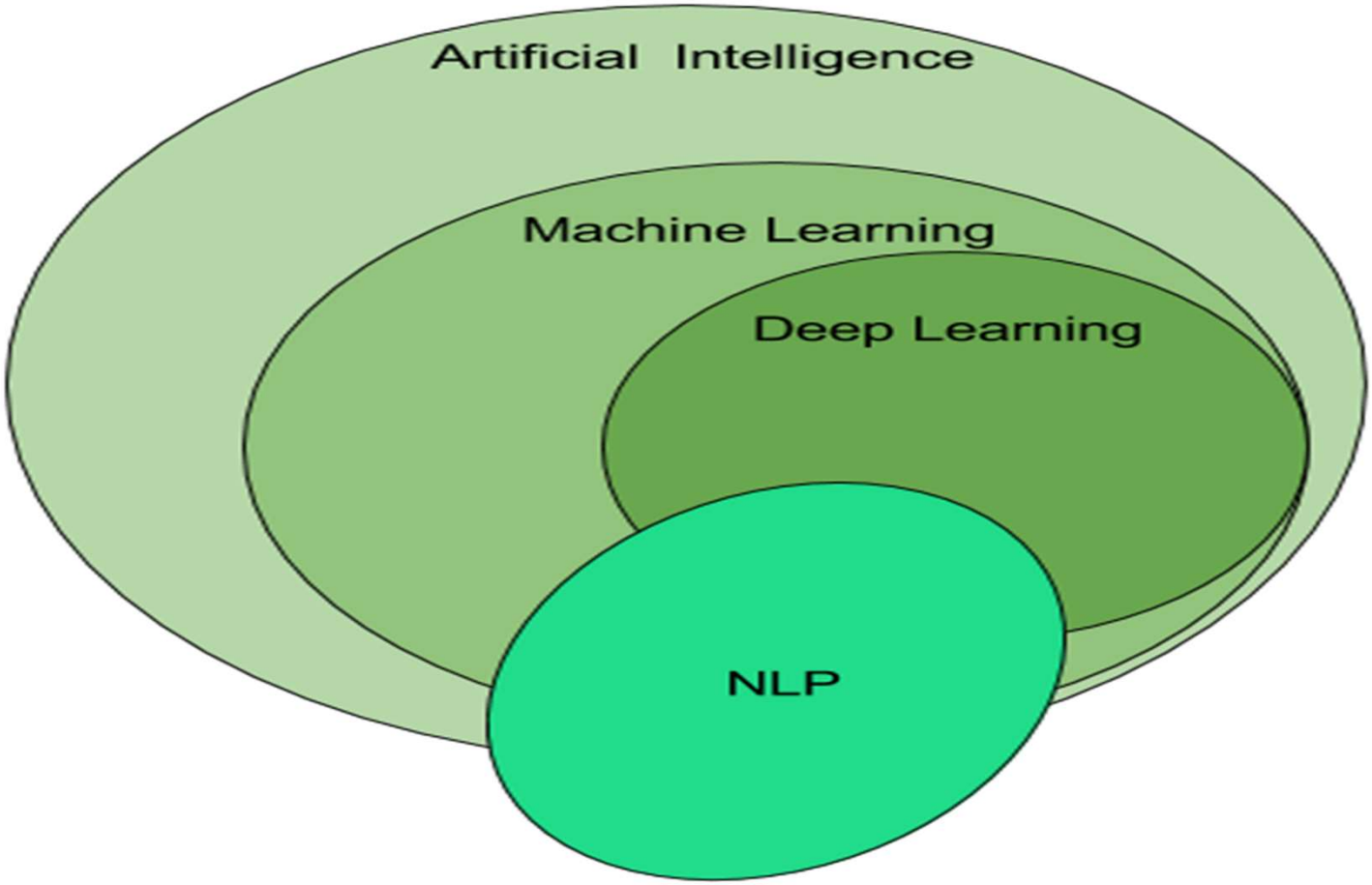
- And many more are there! And
- Many more are coming every year!
- There are many challenges in making such bots -
- But among all challenges "**Human Like Intelligence**" stands out.
- While achieving "**Human Like Intelligence" is our ambition, the path to achieve is a very difficult one! It is a complex multi-disciplinary area!**

- AI, ML, NLP, Data Science, Knowledge, Experience, Cognitive Computing, Life Long Learning and many more!

Human-Like Intelligent Robots/Softbots- 1



Human-Like Intelligent Robots/Softbots - 2



Natural Language based Intelligent Bots

Our Focus

Our focus is on the following to help achieve "Human Like Intelligence" :

- Natural Language Computing, with special focus on Semantic Engine
- Machine Learning with special focus on Unstructured Data & Logic
- Cognitive Computing
- AI with Knowledge, Experience & Reasoning

Automation: Good or Bad?

The Pros

- A SOLUTION TO THE LABOR SHORTAGE
- ELIMINATE MINDLESS TASKS
- INCREASED WORKER SAFETY
- IMPROVED PRODUCT QUALITY, ACCURACY, REPEATABILITY, AND LESS HUMAN ERROR
- HIGHER VOLUME OF PRODUCTION
- LESS EMPLOYEE COSTS

Automation: Good or Bad?

The Cons

- DISPLACEMENT OF MIDDLE-CLASS JOBS
- LESS VERSATILITY
- MORE POLLUTION
- BIG CAPITAL INVESTMENT
- UNPREDICTABLE OR UNKNOWN COSTS
- HIGHER UNEMPLOYMENT RATES?

Automation and Its Impact

- Well, based on history, trend and data, there are MORE Pros than Cons!
- Thus automation is growing fast over centuries!
- In fact, automation is accelerating!
- Machine Learning is a key contributor for the acceleration of Automation!

Huge Impact to the Economic, Social, Cultural and other developments!

Progression of Automation

- Automation started in the late 18th century with mechanization of textile industry - the first industrial revolution (some small scale automation prior to that).
- Second industrial revolution in early 20th century when Henry Ford mastered the moving assembly line and ushered in the age of mass production
- **Third automation -** Manufacturing is going digital

What is Next?

Automation: What is Next?

We See a Clear Trend that the future Automation is going to be "Knowledge & Intelligence Driven" [In fact it already started!]

- Intelligent Agent doing analysis, making decisions and taking actions
- Knowledgebase, Structured and Unstructured Data, and direct Natural Language inputs / outputs
- Machine Learning to Learn on continuous basis (with experience) & Improve performance, accuracy etc.
- Enable all population - non-technical, semiliterate, illiterate and literate people to use it easily.

Key Features of today's Robots

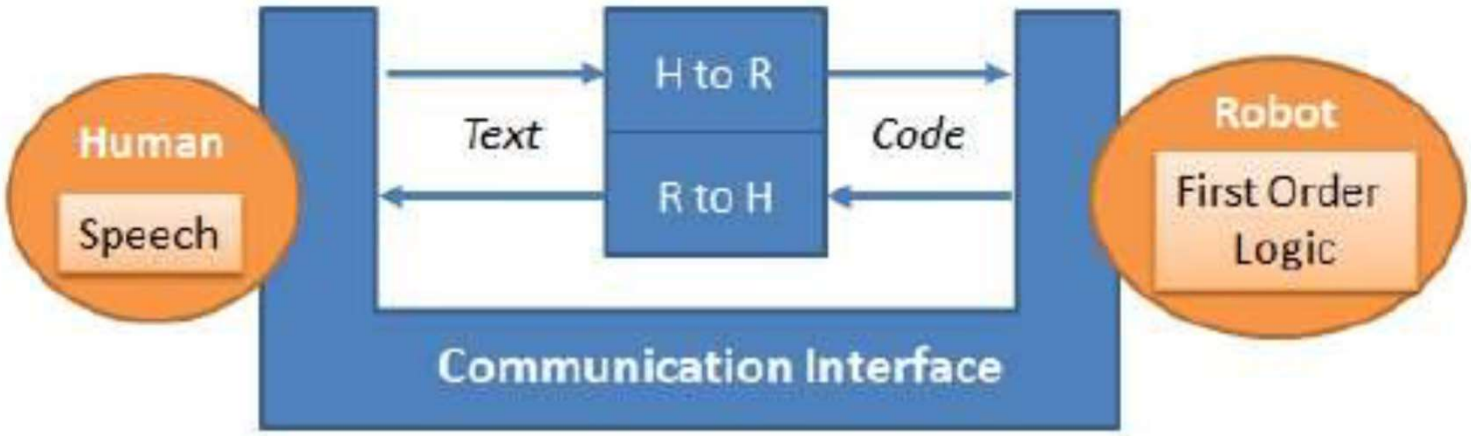
- Human-Robot Cognitive Coupling is key for Telerobots and Cognitive Telerobots
- Human mind mainly focuses on Association whereas digital devices mainly uses comparison!
- Successful communication between human and robots needs to convert human thoughts into numbers, and vice-versa
- Cognitive Robot can Interpret its Own Data. Can Learn from previous experiences

Key Issues with today's Robots

- Controlled Natural Language (CNL, e.g. Attemp to Controlled English [ACL]) is Used to Converted to First Order Logic (FOL) that a robot can use [Next Slide]
- FOL is great but cannot deal with semantics well.
- Efficient Natural Language Processing (NLP)and Cognitive Computing are Limited with existing Semantics approaches (FOL, Frame, Ontology,..)

Human – Robot Cognitive Coupling

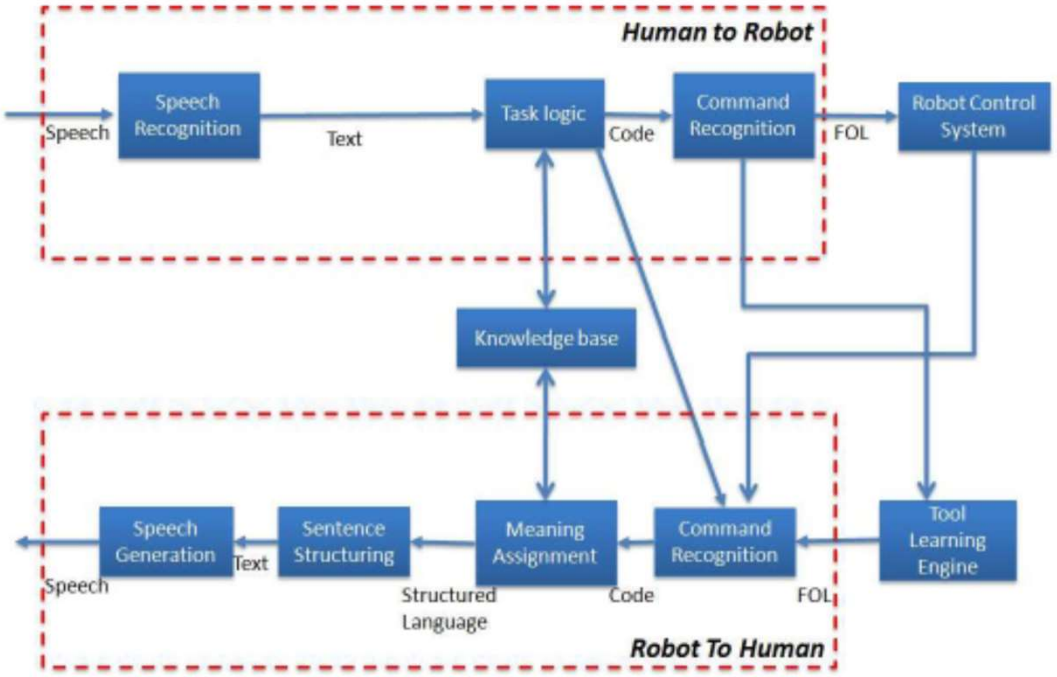
Human-Robot Cognitive coupling (Courtesy Yusuke Inoune et al)



(a) Human and robot cognitive coupling layer.

Human – Robot Cognitive Coupling

Human-Robot Cognitive coupling (Courtesy Yusuke Inoune et al)



(b) Cognitive coupling detailed diagram.

Intelligent Agent based Robot / Softbot

Core Components of IA based Robots / Softbots

- Machine learning (ML) including DL & Life Long Learning
- Natural Language Computing (NLC) [Search space Reduction; simplifies Action computations]
- Semantic Engine
- Artificial Intelligence
- Cognitive Computing [Search space Reduction, Use of Experience]
- Knowledgebase using Unstructured & Structured data
- Others – Analytics, Cloud Computing, IOT, Industry 4.0 as appropriate, RPA (Robot Process Automation)

Intelligent Agent Based Robots / Softbots

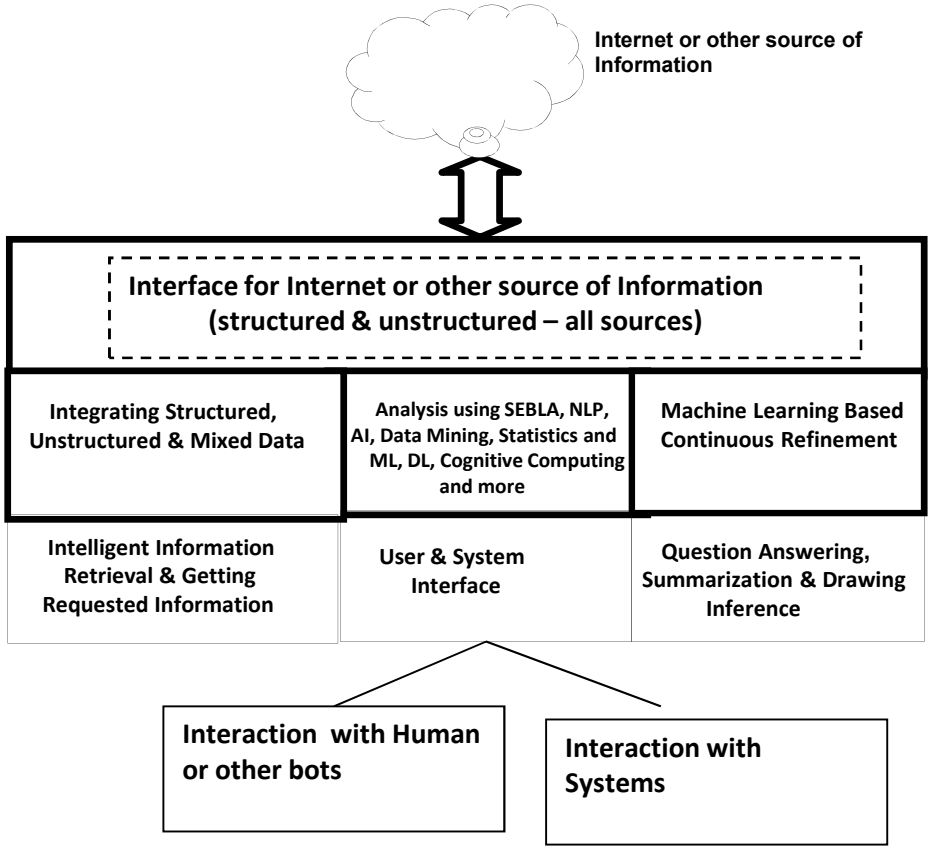


Fig. 1 Advanced Bot: Uses Semantic Engine Using Brain-Like Approach (SEBLA), AI, ML, Data Mining, Statistics and other fields. Intelligent Agent allows NLP based UI and supports all key features including Information Retrieval, Question Answering, Summarization and Drawing Inference and other applications including Manufacturing & Control.

Natural Language in IA based Robots / Softbots

Why Natural Language?

- Structured data represent about 20% of total data
- Unstructured data (80%: *Text, audio, video, image*) dominates & hence More Important (no Known Structure).
- It is a Necessity to address Unstructured data Problems.
- Counting and number based approach does NOT work anymore for Unstructured data (*next slide*).
- Natural Language Computing (NLC) is Now a Necessity.

Unstructured Data: Counting Does Not Work

- What type of count or interpretation can be made
  - From customer feedbacks in a running text
  - From a voice recording of a customer service transaction?
- **How are tweets be interpreted and analyzed?**
- What type of information can be gleaned from customer product reviews?
- What happens when customer reviews are videos?

Addressing Unstructured Data

- Clearly, we need to address Unstructured Data
- We also need to address mixed (Structured & Unstructured) Data
- Hence need to Integrate both in an appropriate way
- Some companies already started doing so, especially using Text Mining using Existing NLP Tools.
- Such Tools use Common NLP Algorithms: *Sentence Segmentation, Tokenization, Stemming, POS (Part of Speech Tagging), NER (Name Entity Recognition), Parsing and some basic semantics.*

Much More Complex Approach Needed for Unstructured Data

- **Much more complex problems to solve to handle Big Data and Data Science needs dominated by unstructured data.**
- **The key is to use NLP based computing (NLC – Computing Using Semantics) with a highly capable and efficient Semantic Engine.**
- **Existing Semantics using Predicate logic, Ontology and the like have issues – need to define semantics for almost everything!**
- **Other key areas are**
  - AI, Machine Learning Related advanced algorithms
  - Natural Language based UI (User Interface)
  - Effective and efficient integration of all these – a complex multidisciplinary Area

Example with Existing Methods for Semantics

- "Maharani serves vegetarian food."
- Semantics represented by existing methods, e.g. Predicate Logic, is
  - Serves(Maharani, Vegetarian Food) and
  - Restaurant(Maharani)
- Now, if we ask

  "is vegetarian dishes served at Maharani ?

  – System will NOT be able to answer

  [we need to define semantics for vegetarian dishes!

  >> Mechanical Semantics]

SEBLA and its Key Concepts

- Semantic Engine Using Brain-Like Approach (SEBLA).
- Considers Each Word as "Semantic Object".
- Semantics of a sentence is calculated by using the semantics of words.
- Semantics of a Paragraph is calculated using the Semantics of Sentences.
- Natural Semantics as opposed to Mechanical Semantics.

SEBLA – Semantics Details

- ***Algorithm to Calculate Semantics:***
  - ***Sentence Level***

- We consider each parsed word in the refined sentence. For each of such word,
  - Get the Function words
  - Get the World Knowledge (WK) words
- E.g. for the word "ball", the function words are {ball, move, roll, round, play..} (includes Features & Functions)
- Function Words defines the semantics or meaning of a word

SEBLA – Semantics Details

Words	Function Words	Function Words with highest membership function value (> 0.9)
ball	Move, roll, round, bounce back, play	roll, round, bounce back, play
eat	Chewing, drinking, putting things in mouth, biting, swallowing,…	putting things in mouth, biting, swallowing
happy	Feeling good, not depressed, excited,	Feeling good, excited
shop	Buy, sell, convenience store,	Buy, sell

Fig. 3: Sample Table for (a) Sample Function Words,

Features of a Fully Capable NLU System

A Full NLU System Would:

- Paraphrase an input text.
- Translate the text into another language.
- Answer questions about the contents of the text.
- Draw inferences from the text.

SEBLA Does These Well -

Existing NLU methods cannot do all these mainly because of the lack of a "Natural Semantic Engine".

Machine Learning in IA based Robots / Softbots

Why Machine Learning - 1

- **Rapidly Growing Need for Automation**
  - Computers & Internet have significantly changed our lives & society.
  - Programming is the KEY for this.
  - Hence Improving & automating "How to program" is VERY important.
  - ML addresses this VERY important part.

- **We do NOT have good algorithms to solve Data Driven problems, for example, Regression, Classification and Clustering:**
  - Spam filtering.
  - Detecting fraud transactions.
  - Reliable Speech Recognition.
  - Auto-driving of vehicles, …..

Why Machine Learning - 2

- Algorithms may exist for some complex applications but they take longer time to run and will be inefficient.

- ML is also the key for Big Data as the data size is very large and complexity is very high; hence algorithms which may exist may run very inefficiently.

- Auto configuration / reconfiguration.

Existing Machine Learning (ML) Algorithms

- Existing ML algorithms mainly address the learning of numerical data. Great success in many applications!
- Such algorithms mainly do Classification, Regression and Clustering.
- Common numerical features (e.g. diameter, weight or shape for coin recognition; or eyes, nose, mouth, eyebrows for face recognition) are used.
- Generalization is inadequate, especially when using complex data, large data or text data.

ML Algorithms for Unstructured Data

- Learning meaning of words, sentences, paragraphs is the key for many natural language applications (Text data).
- Existing ML algorithms (numerical data - Classification, Regression and Clustering) are not adequate for such semantics driven applications.
- Existing methods to define / learn semantics e.g. Predicate Logic / Ontology "mechanical semantics" and can't handle complex tasks.
- New ML algorithms are needed for text driven data.

MACHINE LEARNING PARADIGM FOR UNSTRUCTURED DATA - 1

- NEW PARADIGM IS NEEDED – NEED TO LEARN SEMANTICS
- Machine learning algorithms for natural language semantics (MLANLP) we developed uses a NEW PARADIGM
- Semantics of Words calculate Semantics of Sentences; Semantics of sentences calculate semantics of paragraphs; Semantics of paragraphs calculate the semantics of a document.
- Proper Actions need to be learned / computed in addition to semantics

MACHINE LEARNING PARADIGM FOR UNSTRUCTURED DATA - 2

- **Logic is needed to learn Actions**
- **Semantics & logic driven learning paradigm** mainly uses good explanation / logic rather than training using a large dataset (similar to the way human learns)
- We learn when someone explains or teaches **(uses small number of examples)**
- Semantics driven learning process uses computing and learning at the same time for many cases
- **New Paradigm needs to Derive new Semantics & Knowledge**

MLANLP Example

- **"Show me the pictures of last Saturday birthday party from my Facebook account" [Use Semantics & Logic to understand the Intent & compute Actions]**
- **Understand Intent**
- **Computed ACTIONS:**
  - Go to the Facebook & log on.
  - Calculate the date for last Saturday using today's date.
  - Click link "Fotos".
  - Search Birthday party pictures & get relevant pictures.
  - Present the requested pictures in a nice presentable form to the user.

Cognitive Computing
IA based Robots / Softbots

DERIVING NEW SEMANTICS & KNOWLEDGE: CC - 1

Consider the following 3 sentences:

- I was tired. I fell asleep. Did work and made some good progress after I woke up.
- Need to find **causal relationships** by using the semantics between sentences.
- The semantics of "tired" and "asleep" are related. Then from WK, we know that "tired" caused / may cause "asleep". Thus, the causal relationship between first 2 sentences are established.

DERIVING NEW SEMANTICS & KNOWLEDGE: CC – 2

- In the 3rd sentence "After I woke up" is opposite of "asleep" and hence a relation is established.
- And "made some good progress" is related with not "tired" in the first sentence.
- The basic information in WK will help compute the causal relationship between first sentence and 3rd sentence. Thus, MLANLP will Compute the NEW Derived fact:
- ***"I made good progress" because my "tiredness" was gone due to "sleep".***

Sample Applications

- Manufacturing & Control
- Finance and Banking
- Insurance
- Healthcare
- E-Services (e-Learning, e-Health, e-Farming…)
- Intelligent Search
- Summarization, Inferencing, Question Answering
- Robotic Process Automation (RPA) – Business Process Automation (BPO) with Softbots
- Many more

Intelligent Search

Intelligent Search Means Search That:

- Uses Semantics and Deep Semantics (not just string matching) of NLP
- Uses Meaning of Words to derive the Meaning of the (a) Input String / Sentence and (b) Title of the Results
- Uses Semantic Matching of the Titles with Input Sentence to Derive Results

Demo Using SEBLA (Semantic Engine Using Brain-Like Approach) "Low Price Thai Restaurant Silicon Valley"

DEMO on Intelligent Search

InternetSpeech Intelligent Search Results are:

BEST RESTAURANTS FOR DATES: SILICON VALLEY ... (Not sure about price because menu was taken ... Downstairs ambiance was nice with the low hung light â€¦

... silicon valley restaurant reviews | milpitas ... Barber Ct, Milpitas, CA. 408.526.9888. Pho Tam Thai/Vietnamese. $$. The attractive room belies the low prices.

It was already a famous Silicon Valley restaurant and watering ... low prices , no beer taps (but ... (like the 1980 invasion and conquest of the Bay Area by Thai ...

They have all sorts of Vietnamese fair for really low prices. ... small #9 & a thai ice tea is what i always ... Recent topics in "Silicon Valley" Topic Author Replies

Schmap San Jose and Silicon Valley Restaurants ... but the prices are low and the lunch buffet is a ... Restaurants - Thai San Jose and Silicon Valley - Restaurants

home | restaurants | silicon valley restaurant reviews ... Thai/Vietnamese. $$. The attractive room belies the low prices.

Amber India pretty much owns the Indian fine dining category in Silicon Valley. ... Best Thai Restaurant. ... Delicious, creamy, low fat and just as refreshing ...

San Jose, California dining ... Steak Restaurants; Thai Restaurants; Vegetarian Restaurants; ... Voted Best Steak restaurant by Silicon Valley residents, ...

... silicon valley restaurant reviews | milpitas ... Barber Ct, Milpitas, CA. 408.526.9888. Pho Tam Thai/Vietnamese. $$. The attractive room belies the low prices.

It was already a famous Silicon Valley restaurant and watering ... low prices , no beer taps (but ... (like the 1980 invasion and conquest of the Bay Area by Thai ...

They have all sorts of Vietnamese fair for really low prices. ... small #9 & a thai ice tea is what i always ... Recent topics in "Silicon Valley" Topic Author Replies

Schmap San Jose and Silicon Valley Restaurants ... but the prices are low and the lunch buffet is a ... Restaurants - Thai San Jose and Silicon Valley - Restaurants

home | restaurants | silicon valley restaurant reviews ... Thai/Vietnamese. $$. The attractive room belies the low prices.

Amber India pretty much owns the Indian fine dining category in Silicon Valley. ... Best Thai Restaurant. ... Delicious, creamy, low fat and just as refreshing ...

San Jose, California dining ... Steak Restaurants; Thai Restaurants; Vegetarian Restaurants; ... Voted Best Steak restaurant by Silicon Valley residents, ...

BEST RESTAURANTS FOR DATES: SILICON VALLEY ... (Not sure about price because menu was taken ... Downstairs ambiance was nice with the low hung light â€¦

... silicon valley restaurant reviews | milpitas ... Barber Ct, Milpitas, CA. 408.526.9888. Pho Tam Thai/Vietnamese. $$. The attractive room belies the low prices.

They have all sorts of Vietnamese fair for really low prices. ... small #9 & a thai ice tea is what i always ... Recent topics in "Silicon Valley" Topic Author Replies

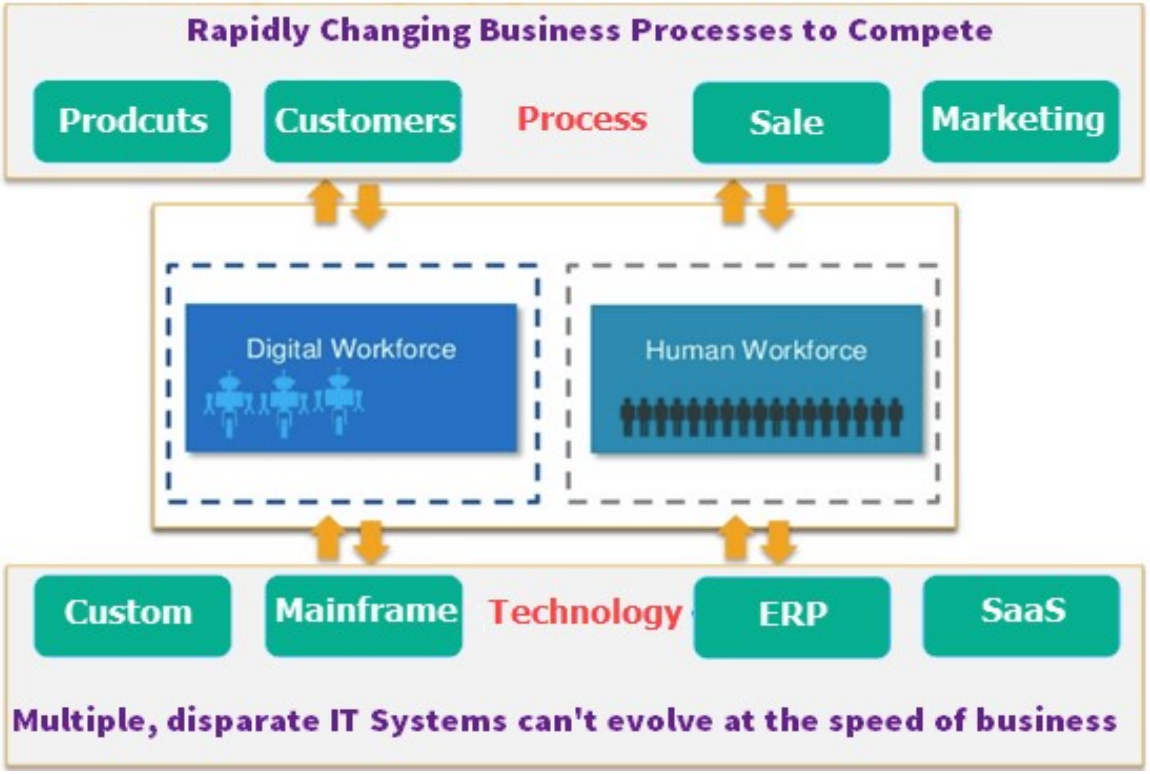
Schmap San Jose and Silicon Valley Restaurants ... but the prices are low and the lunch buffet is a ... Restaurants - Thai San Jose and Silicon Valley - Restaurants

Amber India pretty much owns the Indian fine dining category in Silicon Valley. ... Best Thai Restaurant. ... Delicious, creamy, low fat and just as refreshing ...

[Some Results Taken Out to Fit in One Page]
Total Count of Results: 47

Fig. 2 Search Results for "*Low price Thai Restaurants in Silicon Valley*" With **Intelligent Search** (SEBLA_IS) Using **SEBLA** (Semantic Engine Using Brain-Like Approach) - Courtesy InternetSpeech Corporation (www.internetspeech.com).

Robotic Process Automation (RPA)



Digital Workforce (Softbot) is key for Business Process Automation (BPO) – many enterprises (including Banking, retail, Supply Chain,…)

Natural Language based Intelligent Bots

Final Notes on Natural Language based Intelligent Bots - 1

- Intelligent Bots doing analysis, making decisions and taking actions
- Uses Knowledgebase, Structured and Unstructured Data, and direct Natural Language inputs / outputs
- Uses Machine Learning to Learn on continuous basis & Improve performance, accuracy etc.
- Continuous Learning in Bots is Key to generate Experience – like we do as human.

Final Notes on Natural Language based Intelligent Bots - 2

- **Effectively addresses most key issues with existing bots**
  (Simplifies & Improves Action computations)

- **Make Computations more Effective, Capable and Fast**
  (Significantly reduces search space using semantics)

- **Enable all population - non-technical, semiliterate, illiterate and literate people to use it easily.**

Helping Global Development

- NLP based Computing and Bots will help many more people to enjoy the benefits of the Internet & Information Age in a much more effective and efficient way;
- Enabling many more people around the world, especially, in the underdeveloped and developing countries to effectively bridge the Digital and Language Divides in a practical way.
- Help sustainable global development by focusing on Education, Innovation and Entrepreneurship.

References / Further Reading

[1] E Khan,, **"Natural Language Computing: A Necessity for Cognitive Computing and Intelligent Internet",** 17th International Conference on ARTIFICIAL INTELLIGENCE, KNOWLEDGE ENGINEERING and DATA BASES (AIKED '17), Feb 25, 2017, Cambridge University, U.K.

[2] E. Khan, "**Machine Learning Algorithms for Natural Language Semantics and Cognitive Computing",** The 2016 International Conference on Computational Science and Computational Intelligence (CSCI'16), Dec 15-17, 2016, Las Vegas.

[3 E. Khan, **"Next generation web - intelligent search, question answering, summarization and more",** INTERNATIONAL JOURNAL of COMPUTERS AND COMMUNICATIONS, (NAUN & UNIVERSITY PRESS), Vol. 9, June 2015.

[4] E. Khan, **" Intelligent Internet: Natural Language and Question & Answer based Interaction",** INTERNATIONAL JOURNAL of COMPUTERS AND COMMUNICATIONS, (NAUN & UNIVERSITY PRESS) Oct. 2013.

[5] C. Eaton et al, "**Understanding Big Data: Analytics for enterprise class Hadoop and Streaming Data**", http://public.dhe.ibm.com/common/ssi/ecm/en/iml14296usen/IML14296USEN.PDF

[6] Wikipedia – "**Big Data**" - http://en.wikipedia.org/wiki/Big_data

[7] P. Ryan et al, "**The Problem of Analyzing Unstructured Data**", Grant Thoronton, 2009,

http://www.grantthornton.ie/db/Attachments/Publications/Forensic_&_inve/Grant%20Thornton%20-The%20problem%20of%20analysing%20unstructured%20data.pdf

[8] E. Khan, "**Addressing Big Data Problems using Semantics and Natural Language Understanding",** 12th WSEAS International Conference on TELECOMMUNICATIONS and INFORMATICS (TELE-INFO '13) in Baltimore, MD, USA, September 17-19, 2013.

[9] E. Khan, **"Processing Big Data with Natural Semantics and Natural Language Understanding using Brain-Like Approach",** INTERNATIONAL JOURNAL of COMPUTERS AND COMMUNICATIONS, (NAUN & UNIVERSITY PRESS) January 2014.

[10] E. Khan,: **Natural Language Understanding Using Brain-Like Approach: Word Objects and Word Semantics Based Approaches help Sentence Level Understanding,** US Patent filed on July, 2011

[11] E. Khan, **"Natural Language Processing, Big Data, Bioinformatics and Biology",** INTERNATIONAL JOURNAL OF BIOLOGY AND BIOMEDICAL ENGINEERING (NAUN & UNIVERSITY PRESS), June 2014.

[12] Khan, E., (2011): **Internet For Everyone: Reshaping the Global Economy by Bridging the Digital Divide" published in Aug, 2011; 978-1-4620- 4251-7 (SC ISBN)**