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Cognitive Modeling: Role of Artificial Intelligence

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Abstract**: *The last 40 years of information technology evolution is more about how to automate the processes or tasks that are deterministic in nature. A deterministic task is an activity or a process which will have a sequence of well-defined steps between interaction entities. In such cases, one can develop software to automate the manual process by using any of one of the technology streams like Custom Development (using Java, .net, etc.) or BPM (Business Process Development) or RPA (Robotics Process Automation), etc. The critical component missing in these cases is cognitive nature. Cognitive nature means a process involves psychological thinking, sensing and understating of the knowledge, attitudes, natural behaviors, linguistics, etc.,in order to produce an output or a decision while solving a problem In this paper, we would like to present the application development for cognitive tasks by building Artificial Intelligence (AI) systems.Section I presents introduction, Section II gives basic foundations of AI. A computer program with AI and a computer program without AI have been discussed in section III. Section IV presents the current state of AI systems. Section V elaborates Artificial Intelligence stack and section VI presents the conclusion.***

Index Terms**: *artificial intelligence, cognitive systems, big data, NLP, machine learning.***

I. INTRODUCTION

One of the basic purposes of building software is to automate manual tasks/processes. Graphically, we can explain the classification of processes/tasks based on the nature of work, FTE (Full Time Equivalent) density and other parameters. Since the processes that are in deterministic in nature hence they can be automated through current software development techniques like custom development, BPM, RPA, etc.

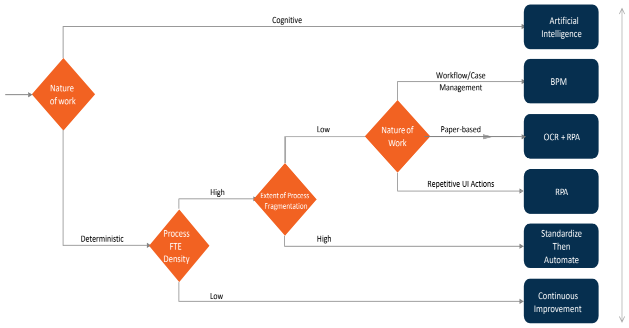

Fig. 1WorkflowClassification

For the processes having nature of work as cognitive, Artificial Intelligence (AI) is the stream to automate the work and to build software applications. In other words, it means AI systems should be capable enough to exhibit intelligent behavior, learn, demonstrate, explain, and advice its users. The only work involved is to create systems that understand, think, learn, and behave like humans. It is ultimately implementing Human Intelligence in Machines.

Technically, the definition of AI is a set of technologies that enable computers to assist and solve problems in ways that are similar to humans by perceiving, learning, and reasoning. AI applications enable computers to learn from vast amounts of data, and interact more naturally and responsively with the world, rather than following pre-programmed routines. AI related technologies are being developed to teach computers to "see," "hear," "understand," and "reason."

Client-Server Revolution is the first information technology concept that captured business data into databases and managed that data through applications. Through this automation, organizationsbuilt applicationlike Customer Relationship Management (CRM), Human Capital Management (HCM) systems for HR, and Enterprise Resource Planning (ERP) systems for handling finances and key assets. This revolution produced Systems of Records.

The second biggest revolution is the Internet. The rise of the internet has led to the creation of web and mobile applications, allowing enterprises to build applications that interface between systems of records and users (consumers, customers, suppliers, dealers, etc.) directly. Overall this revolution produced Systems of Engagement.

The current biggest emerging revolution is AI.It is the System of intelligence, which can understand and reason with the data that gets produced by systems of records and systems of engagement. These systems can drive workflows and management processes, optimize operations, and drive intelligent interactions with customers, employees, suppliers, and stakeholders.

II. BASIC FOUNDATIONS OF AI:

1. Mathematics – It formalizes the three main areas of AI - Computation, Logic, and Probability. Computation leads to the analysis of the problems that can compute complexity theory. Probability contributes the "degree of belief" to manage uncertainty in Artificial Intelligence. The decision theory blends probability theory and utility theory (bias).

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2. Psychology – It is a subject of how do humans think and act? The study of human reasoning and acting behavior gives reasoning models for AI. It strengthens the ideas and how *humans and other animals can be considered as information processing machines.*
3. Linguistics – It helps in understanding natural languages and different approaches adopted from the linguistic work. Ultimately it describes what are the formal languages, the syntactic and semantic analysis and ultimately the Knowledge Representation.
4. Control Theory & Cybernetics –It shows how artifacts operate under their own control and adjust their actions. Also, how to do better for the environment over time based on an objective function and feedback from the environment.
5. Computer Engineering - It gives a solution in building an efficient computer that provides the artifact that makes AI application possible. The power of the computer makes the computation of large and difficult problems easier.

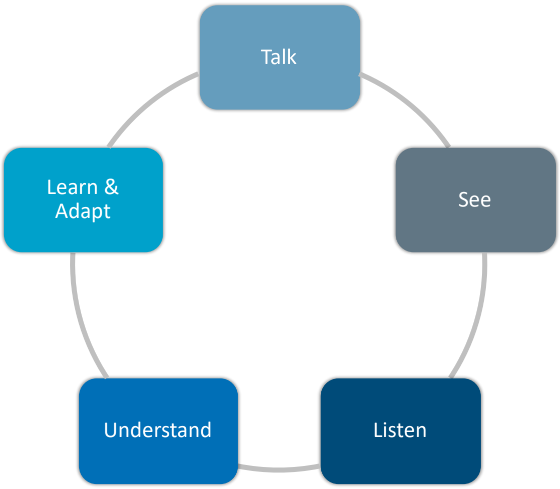

Fig. 2Rational Thinking

III. COMPUTER PROGRAM WITH AI AND WITHOUT AI:

A software program is a set (sequence) of instructions that tells a computer what to do in order to perform a specified job/task. These programs are written using a programming language which is used to communicate instructions to a computer. Basic elements of a program are Input, Output, Arithmetic statements, Conditional statements and Looping statements.

The programs without AI will also have some level of intelligence which is called Artificial Narrow Intelligence (ANI), But Machine intelligence equals or exceeds human intelligence or efficiency at a specific task. The next level is Artificial General Intelligence (AGI) - A machine with the ability to apply intelligence to any problem, rather than just one specific problem (human-level intelligence). The final level is Artificial Superintelligence (ASI) - An intellect that is much smarter than the best human brains in practically every field, including scientific creativity, general wisdom, and social skills.

Programming Without AI	Programming With AI
• A normal computer program (without AI) can process specific tasks it is programmed to process or solve.	• A computer program with AI should be able to process generic tasks it is meant to solve within broader context.
• Any change in business process will impact the program structure and lead to change in the logic.	• AI programs should be coded to absorb new modifications without impacting the program structure.
• Will process the input as coded and produce an output.	• Will produce a program to fit to the context and that program produce the output.

IV. CURRENT STATE OF AISYSTEMS:

Now, the interesting question is do we have the right computers to build AI systems? Can we build hardware that can match with the human brain and intelligence? The challenges can be summarized as below:

In the near future, we can have computers with as many basic processing elements as our brain, but with far fewer interconnections (wires or synapses) and much faster updates. Of course, building hardware is very different from making a computer behave like a brain.

Let’s Review Other Elements - Can Computers Recognize and Understand Speech? – The first thing computer need to figure out is separating the noise out of speech. When it takes the changes in air pressure doesn’t know which are caused by surroundings and which are caused by the actual speech. The sound wave typically very complex mix of waves with different frequencies. Picking out the parts of the sound wave matters in telling the difference between say a “hey” sound and say “hai” sound.A typical speech stream will not have any word breaks. The computer has to figure out to form a string of phonemes by finding valid words. Then need to make multiple guesses on related words and make up the speech stream, but the challenge is not all the guesses make good sequence of words.Humans use a lot of implicit knowledge and commonsense knowledge in communication. Overall the conclusion is NO, it is very complex to recognize and understand speech accurately, it is beyond the capabilities of a computer but YES for restricted speech understanding tasks.

Can Computers Talk? (Speech synthesis). This is the capability of translating text to speech It Scientists have attempted to simulate human speech since the late 1700s. Critical elements in this process are to define and use the pronunciation to map phonemes to actual sound. English contains about 40 unique phonemes. For example, the word "Thanks" is composed of four: T, HA, EN and KZ.

The software need to grab appropriate phoneme out of collection of recorded samples that super voice contains and compose together.

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The challenge with this approach is sounds made by this 'lookup' are not independent and also unnatural. Humans have the capability to have more emphasis on emotion and they understand what they are saying but machines don't, they are artificial. Overall the conclusion is NO, for conversational sentences, but YES for pieces of words.

Can Computers See? – This is the capability of just beyond Face recognition and is more about object recognition. If we read how humans see, the human brain can map a 2D visual image to 3D 'map.' Humans can effortlessly recognize objects, recognize and understand the objects in a scene by looking around a room, etc. There are challenges in representing 3D recognition and Visual Learning.Overall computers can only recognize certain types of objects in limited circumstances (e.g. face recognition) but mostly can't see all.

Can Computers Adapt and Learn? –YES, Machine learning allows computers to learn through building models and training them with data. Deep learning is another revolution using Neural Networks will allow computers to correct/act/react on their own without explicit programming. Overall the conclusion is YES, but information to be presented in an appropriate way.

How complex is human brain?	How Complex a Computer we can build?
• A neuron is the basic information processing unit. • Human Brain will have Approximately 10~12 neurons • Approximately 10~14 synapses connecting these neurons • Cycle time: 10~3 seconds (1 millisecond)	• A CPU will contain 10~6 transistors. • A supercomputer will contain hundreds of CPUs, 10~9 bits of RAM • Cycle times: order of 10 ~ 8 seconds

V. ARTIFICIAL INTELLIGENCETECHNOLOGY STACK:

The capabilities that should be produced by AI applications may be categorized into the key groups as

1. Computer Vision - This is the ability of computers to "see" by recognizing objects and their relationships in a picture or video.
2. Speech Recognition &Synthesis - This is the ability of computers to "listen" by understanding the words that people say and to transcribe them into text, and also to read text aloud in a natural voice.
3. Language Understanding - The ability of computers to "comprehend" the meaning of words and respond, considering the complexities of language (such as slang and idiomatic expressions). When computers can effectively participate in a dialog with humans, we call it "conversational AI."
4. Knowledge Representation- The ability to store information effectively &efficiently and the ability of a computer to "reason" by representing and understanding the relationship between people, things, places, and events.
5. Adaption – It is the ability to adapt to new circumstances based on the learning and previous experiences.

In the context of building enterprise applications, these capabilities are nothing but just like building any other software applications with learning and reasoning taking the centre stage. The power of AI is authorizing applications that reason by unraveling the power of all data collected over a period of time, across repositories and huge datasets through machine learning. These AI-powered systems have the ability to understand and bring meaning in unstructured data such as email, chats, and handwritten notes, all of which was not possible earlier. More importantly, the systems are interacting with customers and engaging them in different channels and in ways that are hyper-personalized.

Three most important developments that are helping to create modern AI are - data & digital transformation, cloud computing, and ML algorithms. Below table illustrates some of the important technologies in use as of today.

VI. RESULTS

AI Component	Tech Category	Technical Stack
Speech Synthesis, Recognition & Understanding	NLP	• NLP Suite (Standford) • Python Natural Language Toolkit • Apache UIMA • GATE
Computer Vision	Vision Image Processing Segmentation Video Tracking	• OpenCV • BoofCV • NASA Vision Workbench • SimpleCV • Tesseract (OCR) • SLIC Superpixels • OpenTL • Vid.stab
Learning & Adaption	Machine Learning & Deep Learning	• DLib • SciPy • TensorFlow • Theano • Caffe • Torch • Kears
Data Management & Knowledge Representation	Big Data	• Hadoop Eco System • Cloudera, MapR, Hortonworks • Spark • Kafka
Process Automation & Automated Reasoning	Robotics Process Automation	• UI Path • Automation Any Where
Infrastructure	Hosting, Processing and Storage	• AWS • Azure

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VII. ANALYSIS:

For analysis purpose we have taken how to use NLP to develop a Question and Answer system. In this section we elaborate how it works and detailed the code and results also. NLP is termed as a capability of a machine to analyze, understand and process natural language which is called as human language that is native to the people. The main aim of NLP is to make conversations between a human and a computer to be exactly like conversations between a human and a human.

Below mentioned are names of few business domains from where enormous amount of data can be extracted. Let us explore the following business uses and look at how NLP makes use of it.

- Customer Care Operations
- Financial Markets
- Recruitment
- Media and Publishing
- Automotive
- Health Care

Now let us take an example of business specific question and answering with NLP.What is Question Answering Systems (QA Systems)? Question Answering Systems (QA Systems) is an automated approach of retrieving correct responses to the questions asked by humans in native language that is in natural language.

Building a QA System can be simplified as below :

1. By creating knowledge base from domain specific articles, logs, raw documents.
2. By marking the collected data with Lucene (Big Data)
3. For each question and answer pair extract the most appropriate articles and use them as features
4. Creating a classifier by using the above features for classifying if the answer is correct or incorrect (Machine learning - ML).

A QA System which requires enormous amount of data and expertise can be used in search engines.Building a knowledge base with the help of NLP using the data which isn't organized in pre-defined manner, plays an important role in Big Data to build relations like key/pair values of data.NLP based text analytics platforms like Linguamatics I2E, ables the text which isn't organized in pre defined manner to be translated into distinct data fields by picking out the key concepts and their relationships in raw documents.

Building of any NLP Engine follows the below concepts :

- Processing data
- Understanding data
- Generating data (answering easy-to-read in language)

Stage 1 - Processing Data (Natural Language Processing(NLP) : This includes structure extraction, identifying and marking sentence, phrase, and paragraph boundaries, language identification, tokenization, acronym normalization and tagging, lemmatization/stemming, decompounding, entity extraction, phrase extraction.

Stage 2 - Understanding Data (Natural Language Understanding (NLU)): This includesOrganizing records, grouping records, Extracting topics, Keyword/key phrase extraction, Duplicate and near-duplicate detection, Semantic search. The need of understanding individual words and phrases, will turn you to micro understanding used for the extraction of individual entities, facts, or relationships from the text which is further useful for doing things like,

- Extracting acronyms and their definitions
- Extracting key entities like people, company, product, location, dates etc.

Keep in mind that micro understanding must be done with parsing the text, which means that the order and words usage are vital.

Stage 3 - Generating Data (Natural Language Generation (NLG))- it can be defined as a process of producing meaningful phrases and sentences in the form of natural language from some internal representations which involves :

- Text Planning: Collecting the appropriate content from knowledge base
- Sentence Planning: Selecting required words, forming meaningful phrases, setting tone of the sentence.
- Text Realization: Mapping sentence plan into sentence structure.

Role of Human Feedback : The foremost way of making NLP adapt is by making it to learn to listen to the feedbacks given by the people who created the natural language who are the human themselves.The core idea of Knowledge Based Question Answering is to convert the natural language query to structured database query.

Example: "what is the price of iphone x?"

In the above given example, the given sentence gets converted to database query say SQL

SELECT price FROM products WHERE name='iphone' and model=`x`;

it returns the answer back to the user.Like: Below are the results of iphone x prices, Please choose the required product.

>Iphone X 64 gb is xx price
>Iphone X 256 gb is xx price

Code for Q&A System Program using Python:

#Importing the necessary libraries
importnltk
importnumpy as np
import random
import string
#Reading in the data from chatbot.txt
f=open('chatbot.txt','r',errors = 'ignore')
raw=f.read()
raw=raw.lower()
#convert the entire text file content into a list of **sentences and a list of words**
sent_tokens = nltk.sent_tokenize(raw)
word_tokens = nltk.word_tokenize(raw)

#converted to sent_tokens
sent_tokens[:2]
#converted to word_tokens
word_tokens[:2]

#Pre-processing the raw text

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```
lemmer = nltk.stem.WordNetLemmatizer()

defLemTokens(tokens):
return [lemmer.lemmatize(token) for token in tokens]
remove_punct_dict = dict((ord(punct), None) for punct in string.punctuation)
defLemNormalize(text):
return LemTokens(nltk.word_tokenize(text.lower().translate(remove_punct_dict)))
```

#Predefined greeting data

```
GREETING_INPUTS = ("hello", "hi", "greetings", "sup", "what's up","hey",)
GREETING_RESPONSES = ["hi", "hey", "*nods*", "hi there", "hello", "I am glad! You are talking to me"]
```

 # Checking for greetings and returning a greeting response

```
def greeting(sentence):
for word in sentence.split():
ifword.lower() in GREETING_INPUTS:
returnrandom.choice(GREETING_RESPONSES)
```

 # scikit learn library for simplest implementation of a chatbot

```
fromsklearn.feature_extraction.text import TfidfVectorizer
fromsklearn.metrics.pairwise import cosine_similarity
```

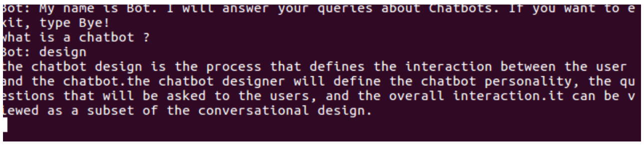
 # Generating response

```
def response(user_response):
bot_response=''
sent_tokens.append(user_response)
TfidfVec = TfidfVectorizer(tokenizer=LemNormalize, stop_words='english')
tfidf = TfidfVec.fit_transform(sent_tokens)
vals = cosine_similarity(tfidf[-1], tfidf)
idx=vals.argsort()[0][-2]
flat = vals.flatten()
flat.sort()
req_tfidf = flat[-2]
if(req_tfidf==0):
bot_response=bot_response+"I am sorry! I don't understand you"
returnbot_response
else:
bot_response = bot_response+sent_tokens[idx]
returnbot_response
flag=True
```

 # Reading the user's input and returning the chatbot conversation

```
print("Bot: My name is Bot. I will answer your queries about Chatbots. If you want to exit, type Bye!") # welcome message

while(flag==True):
user_response = input()
user_response=user_response.lower()
if(user_response!='bye'):
if(user_response=='thanks' or user_response=='thank you' ):
flag=False
print("Bot: You are welcome..")
else:
if(greeting(user_response)!=None):
print("Bot: "+greeting(user_response))
else:
print("Bot: ",end="")
print(response(user_response))
sent_tokens.remove(user_response)
else:
flag=False
print("Bot: Bye! take care..")
```



VII.CONCLUSION

There are many attributes that need to be considered as essential elements in building AI systems including multimodal sensory integration. The success is depends on replicating the important aspect of human concept representation, language processing, and reasoning. There are certain technological breakthroughs in Machine Leaning, Automatic Speech Recognition (ASR), Natural Language Processing (NLP) and computer vision (CV), have resulted in major AI projects and products in Enterprises. Some of the use case categories are Digital personal assistants, chat bots, computer assisted diagnosis (CAD), smart cars, forecast apps, voice and image searches, smart robots, intelligent processing apps, etc. Instead of these breakthroughs, still we are nowhere near integrating multiple modalities as effectively as humans. One key reason is, many things that are needed for AI applications are difficult to capture in data form. Second reason is, there is no approach of abstract reasoning and third reason is, many times it is hard to interpret things which create the accuracy limits. Overall creating multimodal resources (data sets with multi-task nature) will help eliminate the limitation to develop cognitive models and general purpose of artificial intelligence.

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