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The Distributed Processing of Reflex Tasks using Artificial Intelligence

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Abstract:
Artificial Intelligence(AI) is a proliferating technology in the industry. Various flavors of AI capabilities exist in the market spanning the primitive text based chat bots to kinematic robots. Each AI capability possesses specific characteristics, interacts with humans with one or more interfaces. AI based systems are built with the intention to simulate humans in many ways. The concept of distributed AI has been in the industry for a while where each entity does feature extraction and performs inference; such tasks are constrained by its physical resources. The mechanism of fortifying this approach to simulate human intelligence through a ―Reflex Layer‖ is still a gap. Our work extends the distributed AI to inflate and mimic the human system. In this paper we introduce and disclose the concept of ―Reflex Layer‖ and articulate the processing capabilities of key AI components.

Index Terms: Artificial Intelligence, Distributed Artificial Intelligence, Reflex AI.

II. The Logical AI Stack

1. INTRODUCTION

AI solutions have been in existence in the industry in the past decades. However the evolution of ―enabling technologies‖ like Big Data (for compute) and high bandwidth physical layer (for back and forth data movement) has brought the AI technology from labs based ornamental state to production state thus providing value to the business. AI based capabilities are designed to be in par with human systems. Most of the times the AI capabilities get trained involuntarily (also termed as supervised learning) and some get trained voluntarily (termed as unsupervised learning). They get tested, marked for performance metrics and then get put to work in the field. Several research activities are being carried out to evolve the AI system closer to humans for example self- enhancements through exploration [9], remote skill acquisition and through constant human monitoring. One of the key gaps we identified is the ability to differentiate the repetitive stimuli, its related responses and ability to process this through a separate layer. (Note: In reality the human system pushes the response actions for recurring input stimulus to ―reflex layer‖; such stimulus could be from one or more inputs). In section II we intend to recap the various primitives and logical layer of the AI stack. In section III we decompose the AI stack for further components and discuss the characteristics of each component. In

section IV we formally define the Reflex Layer and elaborate the dimensions. In section V we refer the related work and finally conclude.

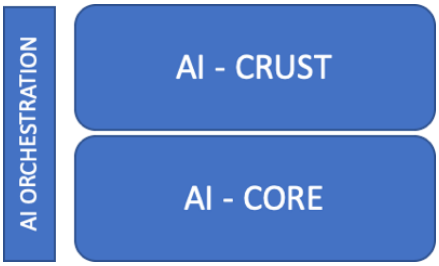

Figure 1: Logical AI Stack

Figure 1 shows the logical view of the ―AI Stack‖ which encompasses the following strata.

- AI Crust ― This is a peripheral dichotomy stratum and hosts various interfaces.
- AI Core ― This stratum hosts the key processing capabilities spanning text mining to extract features and advanced processing capabilities like Machine learning and Deep learning Algorithms
- AI Orchestration- This vertical stratum spans the dichotomy and orchestrates the logic flow and data flow across the primitives of the dichotomy. The vertical stratum interfaces with traditional enterprise applications as and when needed by the business use case.

1. AI Stack contextual View

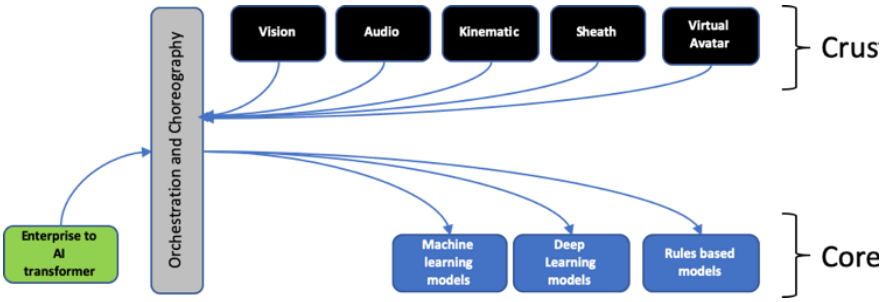

Figure 2: Contextual AI stack

A. The AI Crust

The AI crust encompasses various interfaces of the capability to interact with the external environment.

Following are the key interfaces.

The Vision Interface

Vision interface captures the environment from various angles. The filter types could vary spanning a normal capture to infra-red based capture. The frequency with which the frame is captured can vary for example MPEG frames of 60 frames/sec or other. Advanced vision interfaces have the ability to peer and zoom in to capture specific areas of the frame depending upon the areas of interest to the AI capability. From the frames within the scope, various algorithms operate to extract the features. Many times the frames are pre-processed using techniques of enlargement, gray scale conversion, erosion etc to get better feature values. The extracted features then get fed into the Machine learning or Deep learning pipelines where the images get interpreted. Such interpretations could be interpreting objects, properties of objects ex: cracks in pipes as per the requirement.

The Audio Interface

Audio interface has two parts:

Audio to Text (AT): This is the ingress interface and captures the audio — streaming or static. The captured audio is split into Acoustic and Linguistic components. Engines interpret the temporal, amplitude, frequency, dialect and accent(Linguistics) variations and translate the input audio to text.

Thus the streaming audio gets translated to streaming text. The streaming text is fed to Machine learning and Deep learning algorithms to extract features or interpret the text and associated emotions.The Acoustic and Linguistic components are used to detect sounds of a specific person or object. Text to Audio (TA): This is the egress interface and overlays the text response from the AI system to predefined modulated audio signal and fed to the speaker interface to deliver the audio.Advanced and personalizedTA interfaces are able to overlay the audio to a pre-trained modulated signal.

Kinematic Interface:

Kinematic interface is defined as a tangible interface to perform physical tasks; such tasks could be actions which result in intra or inter- physical changes to objects in the real world. This interface is a complex one and is realized using a number of motors and physical connections. The movement of motors is controlled by centralized AI layer most of the times. Key features defining the behavior of the motor movement is the angular value and tolerance range for the triggered action.

Multiple motors work in parallel or sequentially torecognize a specific task.

Kinematic platform exposes its own interface which will be consumed by the higher AI layer.

The sheath Interface

Sheath Interface is similar to human skin encompassing the intelligence to sense the stimuli. Behind the layer for every stimuli, relevant objects get instantiated. Instantiation of the object(s) would trigger a raft of actions in turn. Advanced sheath not only sense temperatures but also portray emotions like humans.

The Virtual Avatar

Virtual Avatar interface portrays the AI as characters belonging to various categories ex: humans, as objects, animals etc. Virtual Avatars are touch sensitive many times and portray emotions at varying levels.

B. The AI Core

The AI core encompasses a raft of algorithms performing the following key tasks:

Feature extraction:

Feature extraction is the task of identifying entities of interest and optionally extracting the associated value. In reality n number of features need to be extracted and processed to get the results. Such results could be numeric or identifying one or more pre-defined labels. Features adopt a diverse representation in natural language both syntactically and semantically. The feature extraction pipeline needs to identify such variations and converge to the common feature representation. For example syntactically USA means United States of America and United States of America is a value of the feature –Country‖.

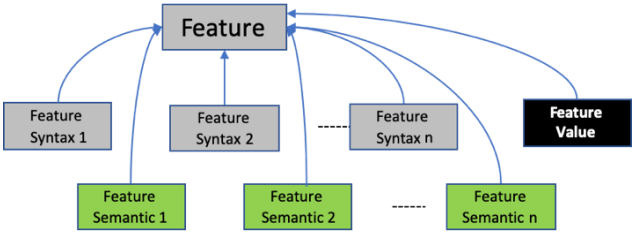

Figure 3: Features

Various machine learning and deep learning models are involved in the extraction of features and values. Neural parsers abstract the models in Natural Language processing, fragment and enable extraction of featuresMachine Learning Models: Various types of Machine learning models exist in the industry spanning the primitive Naïve Bayes Model to complex XG-BOOST, Vector models. Machine learning models most of the times operate in ―supervised model‖ requiring training. Core model gets built using the ground truth (Ground truth is the mapping of set of inputs to the AI capability and the desired output). At run time the model maps the variations in the input to the ground truth and outputs the results with confidence levels. Machine learning models yield one or more of the pre-defined set of output (also called as labels) or computed numeric values as termed earlier.

Deep learning models:

Deep learning models act in un-supervised mode i.e they don't require training. Another key difference is deep- learning models do not require structured data.

They simulate the concepts of human brains and adjust the weightage of inputs automatically to yield the correct

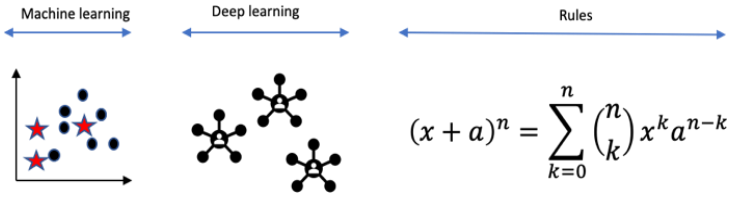

Figure 4: Models

outputs.

Machine learning models and Deep learning models are Probabilistic in nature and should be used to fit the business case against deterministic models.

Rules based models:

Rules based models comply with the programmed foot print and yield deterministic results. There is no concept of confidence levels in Rules based models. Depending upon the use case, rules based models have to be leveraged. In reality end to end solutions may leverage rules based models as well to fit the purpose of business need.

C. Orchestration and Choreography:

Orchestration and choreography layer manages the back and forth flow of messages across various subcomponents. Triggered by the interfaces in the crust, core or enterprise applications, it co-ordinates the flow to achieve the desired outcome.

D. Enterprise to AI Transformer:

Enterprise to AI transformer extracts the ―parts of natural language‖ and maps it to the interfaces of traditional applications. The returned responses from the interfaces in turn get converted to natural language based representation which in turn gets returned back to the end users. Various mechanisms exist to perform such conversions for back and forth. In this section we gave an overview of various key elements in the AI stack. In the next section we intend to discuss the primitives of distributed computing across each ofthese.

2. PRIMITIVES OF AI EMPOWERED FORREFLEX

The concept of Distributed computing gained popular even since 25 years before. Distributed computing enabled the control layer to push the execution across the available resources. In AI based technologies we add a different perception to distributed computing [2] where the individual AI capabilities form a layer called ―Reflex Layer‖.

The Reflex Layer: Definition

We define the Reflex Layer as the layer which is unique to each AI capability and hosts the repetitive stimulus mapped to most common responses. Reflex layer thus empowers the AI capability for local decision making. Reflex layer grows as repetitive tasks are identified thus simulating the human system.

Reflex layer of the vision AI:

Reflex vision (RV) layer of the AI gets formed under the following situations:

- The centralized AI layer specialized in vision processing frequently receives the similar image frames.
- Template (outline) of the object is distinct

The centralized AI layer for vision processing uses a variety of algorithms for edge, corner, blob detection. As an intermediary step encompassing techniques like grey scale conversion, erosion on the images may be applied as we mentioned earlier. When the centralized layer detects similar frames i.e periodically repetitive frames for labelling, it pushes the templates of the objects with labels to the RV layer. RV layer for every image performs erosion/scaling to convert to a common format, performs comparison with the pushed templates and identifies the objects. The RV layer thus gets built up as more and more similar objects get detected; thus objects which pass through this layer are treated as un-seen ones or new ones.

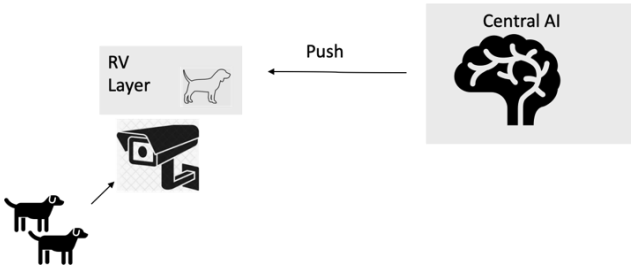

Figure 5: The Reflex Vision

Such a reflex layer possesses advantages to simulate theAI system as humans with the following characteristics:

- Identifies the unseen objects locally and reducesthe load of the centralized AI layer

- RV layer enables faster response of emotions/actions to similar objects
- RV action layer triggers relevant actions of the AI interfaces to portray emotions etc.

Reflex layer of the Audio AI:

Centralized audio layer performs the following tasks:

- Translate the audio in line to text
- Identify the audio and label

Imbibing text capability in RA is complex; however labelling capability is relatively easier.

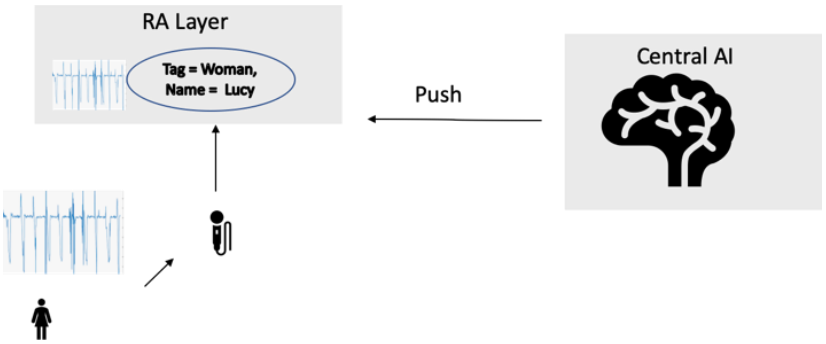

Figure 6: The Reflex Audio

When the centralized audio layer receives frequent similar inputs it pushes the frequency band and audio features with labels to the RA layer. The RA layer thus keeps acquiring intelligence. Inputs which pass through the RA layer will thus be unique ones.

Reflex layer of the Sheath:

Reflex layer of the sheath (Sheath Reflex or SR) just like the skin of humans portrays differing colors for repeated interactions from external stimuli. Such interactions could be as follows:

- Repetitive touch in differing forms at depth/pressure
- Repetitive touch in differing forms at varying frequency (more than one touch)
- Repetitive external temperature ex: sensing hot surface

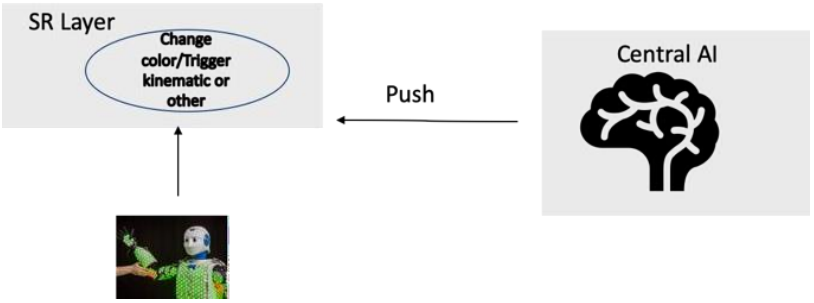

Figure 7: The Reflex Sheath

Centralized AI control layer pushes the responses to the SR layer as repetitions are observed. Such responses could be multiple ones for example changing the color of sheath, triggering kinematic actions to move the part of the AI system (say limb/leg) or others like notifications.

Reflex layer of the Kinematics:

Reflex layer for kinematic (Reflex Kinematic or RK) can be viewed as the one similar to the spinal chord of human systems. This layer hosts the most frequent kinematic actions and responds accordingly

rather than passing it to the centralized Kinematic AI layer. As the centralized AI layer senses repeated inputs from the Kinematic interfaces it pushes the responses to the RK layer. In advanced AI solutions, when the centralized AI is offline (i.e. not reachable), RK layer takes extended decisions.

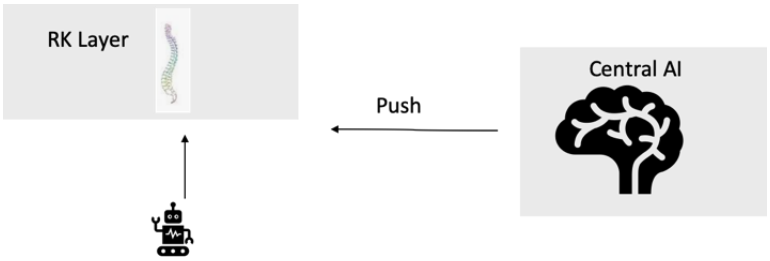

Figure 8: The ReflexKinematic

Actions of RK layer may span a spectrum of actions ranging from simple to very complex categories. Actions triggered by RK layer could be stimulated through various other AI interfaces through the centralized AI control layer.

Reflex layer of Avatar (RAV):

Reflex layer of Avatar adopts the same pattern as the Sheath for touch based interaction.

Reflex layer of core layer (RC):

The core layer encompasses various algorithms encompassing probabilistic and deterministic categories both supervised and unsupervised ones.

Extensive research is carried out to perform distributed computing of the algorithms; however in the context of this paper we refer ―reflex action‖ as the mechanism to execute models in a different layer termed as the RC layer in the following scenarios:

- The centralized control layer has the ground truth which embraces a simple function ex: a linear function say y = f(x) and such function can be executed by the RC
- The number of features are small example lesser than 5
- The model is not being retrained and is static
- The Service Level Agreement (SLA)'s are relatively lesser i.e versions of the models (iterations) which exist as simple functions and output lesser score of precision and recall compared to the versions ofthe same models with complex functions and higher score of precision and recall.

Reflex action – other factors:

So far we discussed the reflex actions from functional perspectives; reflex action could be triggered due to non- functional constraints for example security which prevents the movement of data to core AI which may be in a different cloud or reflex layer possessing surplus resources.

We intend to continue our work for elaborating the methodology of building the following Reflex Layers:

- The RV
- The RK
- The RC

3. RELATED WORK

D Verma and G Bent [2] specify distributed AI through caching mechanisms. This work specifies the shallow model of AI and depending upon the confidence level of the response the necessary policies get invoked. Our work is a broader one compared to this and focusses on the keytypes of AI entities.

B. Thuraisingham, J Larson [8] specify the AI based techniques for front end systems in distributed environment.Our work compliments with this for various external AI interfaces.

4. CONCLUSION

In this paper we discussed the various layers of AI and analyzed the key features of the components. We alsodetailed the reflex layer, its advantages and and focused on reflex layers of various AI components. We intend to elaborate the reflex layer behavior in our future work.

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