A Proposed Algorithm for Ambiguity Reduction with Computational Immune System in HCSI

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ABSTRACT
In the advent of meteorological growth and advancement of computer technologies, things are no more as simple as it was earlier. The Human Computer Interaction (HCI) is concerned with the study, planning, design and uses of the interaction between users and the computers. Till now Artificial Immune System (AIS) is not been deployed for problem solving in HCI.

This study proposes to develop a holistic approach using Artificial Immune System (AIS) to design an interactive system in Human Computer Speech Interaction (HCSI) that minimize the barrier between the human's cognitive model of what the users want to accomplish and the computer's understanding of the user's task by integrating techniques or applications to enable an individual to use the advanced technologies in more interactive manner. This paper proposes an algorithm to develop a prototype with minimal space complexities and to build an Artificial Immune System (AIS) in Human Computer Speech Interaction (HCSI) for avoiding the ambiguity occurs during the speech recognition by proposing two new algorithms i.e. String and Synonym Matching Algorithm (SSMA) and String Comparing Algorithm for Ambiguity Reduction (SCAAR) in the system thereby providing a supportive system that can meet the need of its deliberate users.

General Terms
Algorithm, Ambiguity, Speech Recognition, Synonym, Unimodal System, Multimodal System.

Keywords
Artificial Immune System (AIS), Unimodal System, String and Synonym Matching Algorithm (SSMA), String Comparing Algorithm for Ambiguity Reduction (SCAAR), Human Computer Interaction (HCI), Speech Recognition (SR), Human Computer Speech Interaction (HCSI).

1. INTRODUCTION
Human-Computer Interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them [1]. In other words, Human-computer Interaction is a discipline concerned with the study, design, construction and implementation of human-centric interactive computer systems [2]. The term was popularized by Card, Moran, and Newell in their book, "The Psychology of Human-Computer Interaction", 1983 although the authors first used the term in 1980 [3]. The journey still continues with new designs of technologies and as systems becomes more and more sophisticated each day, the research in this area has been growing at a very fast pace in the last few decades. The growth in the field of Human-Computer Interaction (HCI) has not only been in quality of interaction, it has also experienced different branches of it in its history [4].

2. HUMAN COMPUTER INTERACTION
The concept of Human Computer Interaction (HCI), sometimes called as Man-Machine Interaction or Interfacing [5], [6], was represented with the emergence of computer, or more generic machine. HCI has gained popularity because of its rapidity & ease of deployment. The reason is, most sophisticated machines are worthless unless they can be used properly by men. The main terms of the design of HCI are functionality and usability. Functionality of a system is defined by the set of actions or services that it provides to its users. Usability of a system with a certain functionality is the range and degree by which the system can be used efficiently and adequately to accomplish certain goals for certain users [7].

The available technology could also affect how different types of HCI are designed for the same purpose. Few examples are using commands, menus, graphical user interfaces (GUI) [8], or virtual reality to access functionalities of any given computer [9]. The advances made in last decade in HCI have almost made it impossible to realize which concept is invention and which is and can be genuine. The thrust in research and the constant twists in marketing cause the new technology to become available to everyone in no time. However, not all existing technologies are accessible and/or affordable by public.

The Human Computer Interaction design seeks to discover the most efficient way to design understandable electronic messages. It involves Study, Planning and Design of the interaction between users and computers [10]. There are two types Human Computer Interaction (HCI) Architecture:

2.1 Unimodal:
Only one modality is used i.e. Visual Based, Audio-Based, Sensor-Based etc. [4].

2.2 Multimodal:
More than one modality are used i.e. PC, Smart Phones etc. [4].

3. HUMAN COMPUTER SPEECH INTERACTION
It is a Unimodal Human-Computer Interactive system with which user can interact with the computer through speech commands. With the help of the previously loaded speech commands the user give commands to the computer and the corresponding action are being executed by the system. The speech interaction between the machine and the user can possible if and only if the speech commands are being recognized by the computer [4]. The limitations of Speech Commands are given below:

i. Sometime different words are being recognized by the system.

ii. In a same country there are different users with different accents. Thus sometime it is difficult to recognize the correct commands.

iii. Another main area of difficulty is the occurrences of Ambiguous words during Speech Recognition.

4. SPEECH AMBIGUITY

Ambiguity is a quality of being open to more than one interpretation and inexactness [13]. There are many barriers in the Speech Recognition Technology. The main barriers are Homonyms, Homographs, Homophones and Mistype due to different accents of different people. The Homonyms are the words that have the same spelling and same pronunciation, but different meaning [11] [15]. The Homographs are the set of words those have the same spelling, but different pronunciations and meanings [15]. And the Homophones are the set of words that have the same pronunciation, but different spelling and different meanings [12], [14], [15]. The Table.1 shows the comparison study between Homonyms, Homographs & Homophones.

Table 1. Comparison between Homonyms, Homographs & Homophones

	Spelling	**Pronunciations**	**Meaning**
Homonyms	Same	Same	Different
Homographs	Same	Different	Different
Homophones	Different	Same	Different

The sample dataset of the causes of the Ambiguity occurrences in Speech Recognition Technology are given below in the Table 2.

Table 2. Table captions should be placed above the table

Homonyms	**"*Break*"** [An unexpected piece of good luck, A personal or social separation, A pause from doing something etc.] **"*Run*"** [The act of testing something, A race run on foot, An unbroken series of events etc.] **"*Play*"** [A dramatic work intended for performance by actors on a stage, A preset plan of action in team sports etc.] [15]
Homographs	▪ **"Live"** [Remain Alive, make one's home in a particular place] ▪ **"Wound"** [Noun - An Injury, Verb – inflict a wound on] ▪ **"Close"** [Lock, a short distance away] [15]
Homophones	▪ **'Write'** & **'Right'** ▪ **'Night'** & **'Knight'** ▪ **'I'** & **'Eye'** [11], [12]
Mistyping due to different accent	▪ '**sand which is there**' vs. '**sandwiches there**' ▪ '**example**' vs. '**egg sample'** ▪ '**some others**' vs. '**some mothers'** and also vs. '**smothers**' ▪ '**real eyes**' vs. '**realize**' vs. '**real lies**' ▪ '**a dressed**' vs. '**addressed**' ▪ '**them all**' vs. '**the mall**' '**one-sided**' vs. '**once I did**' [14]

5. ARTIFICIAL IMMUNE SYSTEM

Artificial Immune System (AIS) is a general framework for a distributed adaptive system and could, in principle, be applied to many domains. Many properties of Natural Immune System (NIS) are incorporated by an Artificial Immune System (AIS) i.e. distributed computing, diversity, error tolerance, dynamic learning and adaptation and self-monitoring. The AIS is basically using the Natural Immune System (NIS) as a metaphor for solving computational problems. Basically it is a sub field of Bio-Inspired Computing (BIS) and Natural Computation (NC) with interest in Machine Learning and belonging to the broader field of Artificial Intelligence. It detects rare or suspicious events by borrowing computational ideas from the immune system.

In this paper, Artificial Immune System (AIS) is applied for ambiguity reduction occurs during Human Computer Speech Recognition (HCSI). The next section proposes a new algorithm for reduction the occurrences of different ambiguous words in Human Computer Speech Interaction (HCSI).

6. ALGORITHM OF PROPOSED SYSTEM

The algorithm for the proposed system is described below. **Fig. 1** shows the flow of the proposed system.

1. START
2. INITIALIZE C to 0, L (Limit Set by the Programmer), Text[] (Holds the input string one by one up to L)
3. Input of Voice Command of the User
4. Apply Any Existing *"Speech to Text Conversion Technique"* on the Input Voice Command
5. Text[C]← Converted String
6. C←C+1 // Value of C will be incremented to count the no of input string by the user
7. APPLY **SSMA** to Recognize // SSMA is to be Focused in the Proposed Research
    a. IF Recognized THEN DO Corresponding Action

b. IF Not Recognized THEN Check C>L //L is used as a limit to store the input string in Text[] so that the wrong input can be compared with the correct input for checking whether they can be accepted as a correct string by the system from next onwards.

i. IF Yes THEN // Yes denotes that the Limit has been crossed

1. C←0 & Text[]← NULL // It denotes that the Text[] are reset and all previously stored string are deleted
2. REPEAT Step – 3

ii. REPEAT Step – 3

8. CHECK C>1

a. IF Yes THEN

i APPLY **SCAAR** // Applying SCAAR the proposed system can check whether the input strings that are similar to a correct preloaded string which has been considered as wrong input string in SSMA, those can be accepted as a correct input string by the proposed system from the next time onwards or not. This algorithm can work as Artificial Immune System.

ii GOTO Step – 9

b. IF No THEN GOTO Step - 9

9. Ask User Whether He/She wants to give Another Command

a. IF Yes THEN

i. C←0

ii. REPEAT Step – 3

b. IF No THEN GOTO Step – 10

10. END

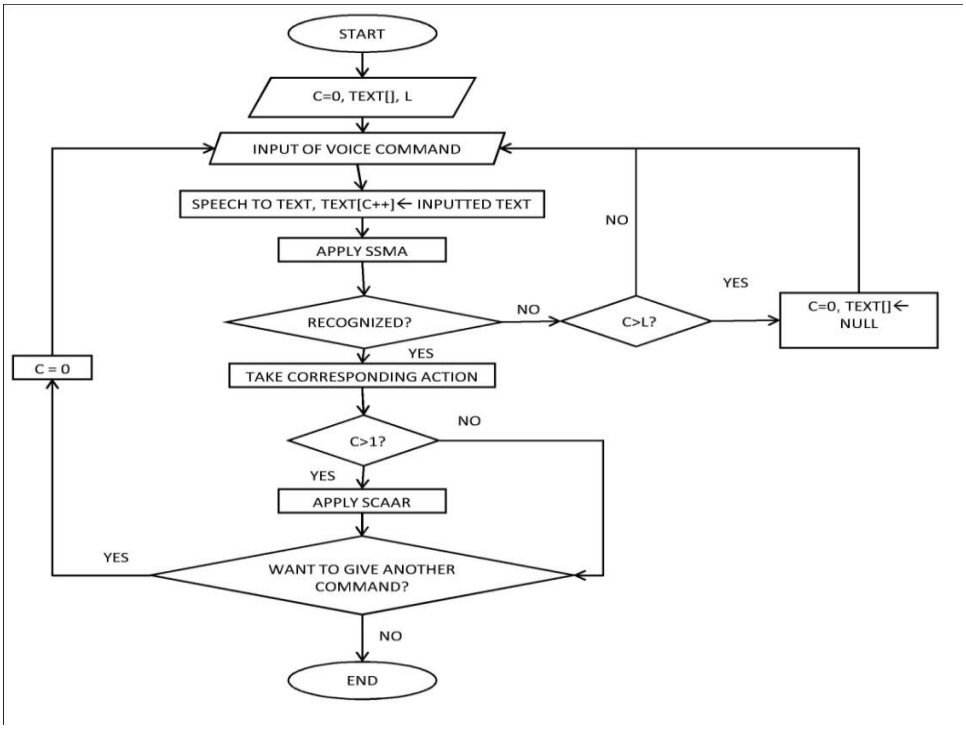

Fig 1: If necessary, the images can be extended both columns

7. ELLABORATION OF PROPOSED SYSTEM

The proposed research focuses on the Ambiguity that exists in most of the Human Computer Interactive System. The proposed System will work on a **Speech Recognition System (SRS)**. The system will first take an input of an acoustic signal from the user. It will then convert the acoustic signal to the text applying **Speech to Text Technology (STT)**. The given text are saved in a **Text[]** array which is a String Array. Then on that inputted text the **String and Synonym Matching Algorithm (SSMA)** will be applied. The basic function of the **SSMA** is to compare the current inputted string with the previously stored string available in the Database. The **Counter C** counts the number of the inputted strings in the string array. If the inputted string recognized then the system will take the corresponding action. After that if the value of the **Counter C** is greater than 1, the system will ask to the user for giving another command. It is upon the user that he/she wants to give any other command to the system or wants to quit the system.

If the inputted string doesn't matched with the previously loaded database, then the system will again take another input from the user subject to a Limit L. The Limit L is set by the programmer dependant on the requirements of the system. If the **Counter C** exceeds the **Limit L**, then the System will take new input from the user and delete all the previously stored

strings from the **Text[]**. If the **Counter C** doesn't exceed the **Limit L**, then one by one the user given strings are stored in the **Text[]** array. If any wrong input is given by the user, then the user must try to give the input again. If the user is able to give correct input after few wrong inputs and before satisfying the check point of **C>L**, then all the previously inputted strings are compared with the accepted string by applying the **SCAAR**. If it is possible to accept any one of the incorrect strings rejected by **SSMA** which is similar with the accepted string and then will be stored in the Database so that from the next time onwards the rejected string will also be accepted by the system in the first time only and from the next time when user is giving that particular string, then that will work as similar as like the previous accepted command with which it was compared. In this way the system will act as an Artificial Immune System which may be unable to understand any unknown command in the first time, but from the next time onwards it will able to identify the same command and take necessary actions. The comparison technique done in **SCAAR** is applied to avoid the ambiguity which may occur for many cases in this proposed research. For example, a system may not be able to recognize the correct command due to the accent of an individual or due ambiguity thereby resulting in unrecognizable command.

The proposed research will focus on the two algorithms **SSMA** and **SCAAR** to avoid the ambiguity occur during giving different inputs to the proposed system. In the SSMA, another approach is to be proposed. The SSMA will also accept the synonym of the stored text in the system database so that the synonym will also be accepted by the system and the corresponding action will be executed. This approach will reduce the system database up to some extent and the system will more interactive applying this approach.

7.1 String and Synonym Matching Algorithm (SSMA)

The String and Synonym Matching Algorithm (SSMA) is proposed to execute two different procedures together.

- One is to compare the Input String with the Preloaded Stored String Commands in the system database. It will check directly that the Input String is fully matched with any of the Preloaded Strings or not using string comparing algorithm.
- Applying the second technique of the algorithm the proposed system will accept the synonym of the given inputted string with the Preloaded Stored String so that the system can reduce the storage memory of the database up to some extent.

7.2 String Comparing Algorithm for Ambiguity Reduction (SCAAR)

The String Comparing Algorithm for Ambiguity Reduction (SCAAR) is proposed to compare between the rejected strings with the accepted string by the system. In the proposed algorithm, it can be seen that the system is storing the inputted string into the **Text[]** array one after another till the system accept any string subject to the Limit L. In **SCAAR**, the Strings **Text[0 to C-2]** will be compared with **Text[C-1]** (the last accepted string by the system) so that whether it is possible to accept any of the previously rejected string on behalf of the last accepted string **Text[C-1]** or not. Applying this algorithm the Proposed System will also be able to accept new strings as a command from the next time onwards which is the basic nature of an **Artificial Immune System (AIS)**.

8. CONCLUSION

In the modern era the **Human Computer Interaction (HCI)** Design faces lot of challenges. Several number of Human-Computer Interaction (HCI) Methodologies can be used to design in a very efficient way by applying proper algorithms, so that implementing those design the Human Computer Interaction will be improvised comparatively to the existing system. The new field of Artificial Immune System is very new field to be explored. This research shows how Artificial Immune System (AIS) can reduce the ambiguity in Human Computer Speech Interaction (HCSI).

As a future scope it can be said that the ***"String and Synonym Matching Algorithm" (SSMA)*** and ***"String Comparing Algorithm for Ambiguity Reduction" (SCAAR)*** is to be explored. The String and Synonym Matching Algorithm (SSMA) will reduce the system database to some extent and the "String Comparing Algorithm for Ambiguity Reduction (SCAAR)" will reduce the ambiguity in Human Computer Speech Interaction (HCSI).

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