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SENSORIUM: A BOT FOR HUMAN SENSORY SYSTEM

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Abstract—In today's era of automation, artificial intelligence is a necessity. Right from doing a simple to a very complex job, all can be handled by a simple artificially intelligent BOT. Human beings perceive the environment with the help of their senses. But it is very difficult for the computer to do so. There are various situations where human intervention is close to impossible. The existence of a robot comes into picture under such circumstances. In order to achieve efficient decision making it is primary to simulate the 5 basic senses in the system. In the proposed approach, speech sensors will recognize the audio input by semantic analysis using tokenizer and parser, thus activating the image sensor. Further, the sensor will identify the image or the object shown using image processing and respond in the form of audio. Another aspect focuses on detecting of particular gas with the help of smell sensor. In case of taste sensing, the system will pick out the chemical content of the compound and accordingly the taste will be determined. Finally, to ascertain whether contact is established, temperature of the object will be diagnosed using the combination of touch and temperature sensors .In all the above scenarios, for respective inputs corresponding audio output will be given. This approach has several applications in areas like home automation , military, etc. Limiting the scope , the system replicates the human senses to some extent .In future, deep learning aspect will help the system to work with more efficiency and achieve better throughput based on the knowledge inculcated.

1. INTRODUCTION

A human body has five senses namely vision, smell, taste, touch, and hear with the help of which an individual can see the world, sense different kinds of smell, recognize different tastes, and respond or communicate after hearing. But there are situations where these human senses won't cooperate at their level best. Consider an industry, where a human has to work in the environment hazardous gases, has to test some food product which may have poisonous substances, has to monitor the flow of any work using his eyes where brightness is low, and has to sense audio in a noisy environment for communication. Therefore the role of an artificially created sensors that could work on behalf of the humans for better outcomes. But these sensors work independently.

The proposed system has all the five human senses which work in co-ordination with each other thus provides cost benefits. Hence the system can be used in war zone areas, under water ,in space for research, etc.

2. BACKGROUND

AI(Artificial Intelligence) is the domain where a machine works intelligently similar to a human being, and it is made to do things and think in a way a particular individual will think. Necessity of a human being to live is his five sensory organs, hence it is vital to simulate them into a robot so as to make impossible tasks in adverse conditions happen accurately and efficiently. This serves as the basic motivation in developing such a prime project. Also, upon developing this, the social cause will be served. Before discussing what actually the project consists of, we need to be aware of some of the concepts related to speech to text conversion and vice versa, how any particular component can be sensed, image processing with the help of some algorithms and Raspberry Pi functioning. Basic knowledge of all the above mentioned terms is necessary for all the problems that prevail in today's world. Under domain of AI, we will be working on technologies such as NLP, Computer Vision, Sensors and Actuators, Speech Recognition and Object Recognition. Sensors are devices that detects and responds to some input type from the physical environment. NLP is the ability of the computer program to understand human language as it is spoken. This algorithm is used in the speech recognition module of an artificially intelligent system. Computer vision is concerned with the automatic extraction, analysis and understanding of useful information from a single image or a sequence of images. It involves the development of a theoretical and algorithmic basis to achieve automatic visual understanding. Object recognition is the ability to perceive an object's physical properties (such as shape, colour and texture) and apply semantic attributes to it (such as identifying the object as an apple). This process includes the understanding of its use, previous experience with the object, and how it relates to others.

3. RELATED WORK

Most of the research papers followed a traditional literature survey for all the 5 modules. Some works proposed innovative ideas and some gave designing techniques. Few authors use NLIDB(Natural Language Interface Database) for speech pro-cessing. In case of shape recognition, Canny Edge Detection Technique was used to detect basic geometric shapes. In the work for identifying taste, ion selected sensory array, signal processing , pattern recognition using LVQ algorithm was proposed. In an approach for determining smell, a unique artificial nostril design was put forward.

1) In the paper 2-D Geometric Shape Recognition Using Canny Edge Detection published in IEEE in the year 2016[1] discusses Canny Edge Detection algorithm.

The algorithm serves good for simple object and mathematical figures. The primary advantage of the algorithm is that it reduces the amount of noise in the image to a great extent. The drawback of this algorithm is it cannot recognise complex shapes.

2) In the paper Electronic Tongue based Liquid Identification using LVQ Algorithm published in IEEE paper in the year 2015[2] implements Linear Vector Quantization. The algorithm results in the comparative study of pH values of different liquids. The biggest advantage of this algorithm the swift reduction and cost is reduced. The drawback of this model is that the computational cost of this model is high.

3) In the paper Development of a Feedback device of Temperature Sensation for a Myoelectric Prosthetic Hand by using Peltier Element published in the IEEE, year 2016[3] uses Temperature Prediction algorithm in order to predict the temperature of the body in contact. The algorithm outputs the temperature in a very less time and thus the time of late response is resolved. The algorithm proves to be difficult to operate the feedback device due to open loop controlled device.

4) In the paper A rule based approach for NLP based query processing published in IEEE 2015[4] implements natural language processing and uses CFG based system.

The algorithm results in creation of sample database that is convenient , reliable and easy to access. The algorithm needs regular updation due to word specific system.

5) In the paper Bio-Inspired Smell Sensor : Nostril Model and Design published in the IEEE 2015[5] paper discusses the design for artificial nostril using olfactory cycle. The design uses ANN and exhalation property which results in faster de-saturation. The Ventilation System including inhalation, sampling and exhalation improves sensors response characteristics. The drawback of the design is as distance increases from the odour source, the time to sense the signal also increases.

This report mainly focuses on NLP for speech recognition, rule based algorithm for smell and touch detection and tensorflow for image recognition.

4. METHODOLOGY

The system will be functioning when it is questioned and in the poling condition i.e. if input is given without asking question. Fig. 1 shows the system overview diagram.

Initially, natural language speech input is given to the system and on receiving that input, the system will initialize all the sensors. The speech input is converted to text. Based on the tokens generated from that input, the corresponding sensors would be enabled. Once the sensor is enabled , it will take necessary input and specific algorithm would convert it to speech output.

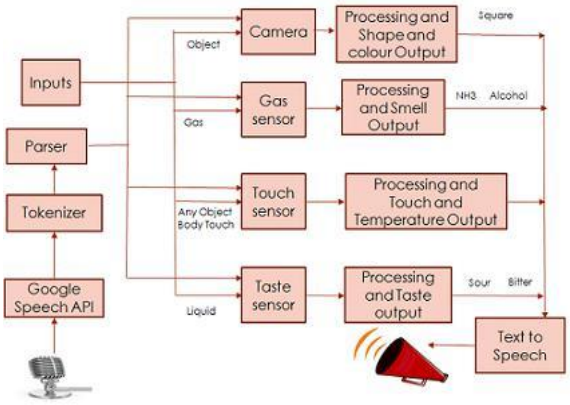

Fig. 1. System Overview Diagram

If the camera is enabled, it will take image input and then process it. Tensorflow[6], a neural network approach is used for image recognition. If the touch sensor is enabled, it will take object input and then process it. Further, when the input is accepted by the touch sensor, it applies temperature prediction algorithm to process that input generating an intermediate output.

If the smell sensor is enabled, it will take gas input and then process it. Further, when the input is accepted by the smell sensor, it applies olfactory sensing algorithm to process that input generating an intermediate output. The required output gets converted into speech using text to speech converter indicating the final output.

When the system is initialized Algorithm Main is called. The steps for the same are as follows:

Algorithm Main:

Step1: Boot the system and Raspberry Pi[12].

Step2: Call the Speech Recognition Algo.

Step3:

if (match 'what' and 'image') then call Object Recognition Algorithm.

if (match 'what' and 'smell') then call Smell Recognition Algorithm.

if (match 'is' and 'contact') then call Touch Recognition Algorithm.

if (match 'exit') then goto Step

The first Algorithm called by the Main is Speech Recognition.

The algorithm converts the speech into textual format. This text is further parsed and tokenized by nltk[] ,which is used for extracting keywords and respective module activation.

Algorithm Speech Recognition:

Step1 :Import Speech Recognition package[9].

Step2: Initialize Recognizer and Microphone object.

Step3: Call the listen function.

Step4: Print text.

If the keywords extracted from Speech Recognition algorithm are matched i.e. compared with 'what' and 'object' or 'image' and found true, then the Object Recognition Algorithm is called. The flow for the same is as follows:

Algorithm Object Recognition:

Step1: Using opencv[8] enable webcam and capture the image.

Step2: Process the image using tensorflow library[7].

Step3: Return the classification of the image among trained classes.

Step4: Return the class having highest probability.

If the keywords extracted from Speech Recognition algorithm are matched i.e. compared with 'what' and 'smell' and found true, then the Smell Recognition Algorithm is

called. The smell sensors viz MQ2 and MQ3 are mounted on Raspberry Pi. Each sensor gives binary output, either true or false. A rule based approach is used for detecting the output.

The steps for the same are as follows:

Algorithm Smell Recognition:

Step1: Boot the Raspberry Pi.

Step2: Import RPi.GPIO package.

Step3: Set Mode as Bcm or Board.

Step4: Set Input Pins.

Step4: if Input is True return Detected.

If the keywords extracted from Speech Recognition algorithm are matched i.e. compared with 'is' and 'contact' and found true, then the Touch Recognition Algorithm is called.

The capacitive touch sensor viz TTP223B is mounted on Raspberry Pi. The sensor gives binary output, either true or false. A rule based approach is used for detecting the output.

A human body has multiple receptors for sensing touch and temperature which are placed closely as an array. The same is concept used in the proposed system. So as an application of touch the system will also be detecting the temperature using DHT11 sensor that is also mounted on Raspberry Pi. The steps for the same are as follows:

Algorithm Touch Recognition:

Step1: Boot the Raspberry Pi.

Step2: Import RPi.GPIO package and Adafruit DHT package.

Step3: Set Mode as Bcm or Board

Step4: Set Input Pins.

Step5: if Input is True return Detected.

Step6: Read input from DHT11.

Step7: if Temperature is not None then return Temperature.

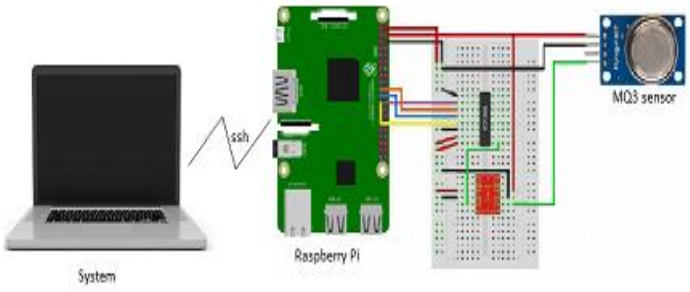

Fig. 2. Experimental Design

5. EXPERIMENTAL DESIGN

The hardware requirements for the experimentation of the system are as follows, a system(PC , laptop) having web camera, microphone, speakers, Raspberry Pi 3 Module B[12],MQ2(alcohol detection) sensor, MQ3(smoke detection) sensor, capacitive touch sensor TTP223B, DHT11 temperature and humidity sensor, wires. The software prequisites before the implementation are as follows, Linux operating system, python3, Google speech recognition api[9], nltk(natural language tool kit for parsing)[10], pyttsx3(text to audio speech)[11], tensorflow[6], Raspbian OS[12](to be installed on raspberry pi).

The experimental design is shown in figure 2. The raspberry pi(RP) is remotely connected to the system(PC) using 'ssh'. The sensor(S) mentioned above are mounted on raspberry pi

using wires[]. The speech recognition, object recognition, and speech output module are implemented on the system. The smell and touch recognition module are implemented on raspberry pi. The general flow of how the system will be working is as follows. Firstly the system is initiated. Further the user will ask finite set of questions viz 'what is the image' , 'what is the smell', and 'is there a contact'. Processing the above audio input (questions), respective module will be activated as mentioned above in the methodology section. The output is in the form of audio that tells sensed smell, touch, temperature and the object recognized. Also there are situations where the system ought to sense smoke or leakage of any gas or sense touch without any question or audio input. Hence the proposed system is also implemented in a polling condition i.e functions if input is sensed by it other than speech input. For object recognition the system is trained for following list of objects

viz ball, roses, watch, water bottle, banana, apple. Only smoke and alcohol containing components like propanol, thinner, deodorant are sensed by smell recognition module. Any object establishing contact with the touch sensor can be sensed. The DHT11 senses the temperature and humidity from the surrounding environment.

6. RESULT AND DISCUSSIONS

This chapter deals with the results after the execution of the system under various circumstances. The chapter also gives an idea of the situations in which the system works efficiently.

TABLE I
SPEECH MODULE CONFUSION MATRIX

n=150	Predicted : What is the Smell	Predicted : What is Object	Predicted : Is there a contact	Predicted : Misc
Actual : What is the smell	120	15	6	0
Actual: What is the Object	10	110	5	20
Actual:Is there a contact	0	2	130	18

The following are some of the key factors over which the systems functionality depends.

1) Internet connection : Faster Internet connection would yield better results for the speech recognition and hence the overall system functionality would be efficient.

2) System Camera : The image being captured should focus on the primary object in the frame so as to get the best object recognition results.

The system yields quite accurate results when all the above mentioned scenarios are taken into consideration. In a noisy environment, the system may yield inaccurate results due to the impact of the ambient noise. The following confusion matrices gives an idea about the actual output and the expected output module wise.

The matrix Table I briefs about the speech module. It gives a detailed analysis of how the speech module respond to each of the given input by the user, considering the actual and the predicted output given by the system.

The Table II gives a brief idea of the number of times the system ends up giving correct results for image or object recognition module .The confusion matrix Table The confusion matrix Table III shows the degree of correctness in detecting the smell of the input gas. The matrix Table IV depicts the number of times the system detects the contact of the object. Integration testing, in context of the system, is the testing of various modules with the dependencies taken into consideration. That means, integration testing deals with the impact of the one module over other module.

TABLE II
IMAGE RECOGNITION MODULE CONFUSION MATRIX

n=150	Predicted : Ball	Predicted : Water Bottle	Predicted : Roses	Predicted : Watch
Actual : Ball	126	15	6	3
Actual: Water Bottle	10	113	5	22
Actual: Roses	19	11	100	20
Actual : Watch	5	20	15	110

TABLE III
SMELL DETECTION MODULE CONFUSION MATRIX

n=150	Predicted : Smoke	Predicted : Alcohol
Actual : Smoke	145	5
Actual: Alcohol	10	140

In case of our system the speech module is integrated with all the other 3 modules viz. smell, touch and image recognition. The following Table V depicts the various scenarios for the integration testing results.

TABLE IV
TOUCH DETECTION MODULE CONFUSION MATRIX

n=150	Predicted : Detected	Predicted : Not Detected
Actual : Detected	142	8
Actual: Not Detected	2	148

TABLE V
INTEGRATION TESTING RESULTS

Primary Input	Secondary Input	Actual Output	Expected Output
What is the image	Ball	This is ball	This is ball
What is the smell	Smoke	Smoke Detected	Smoke Detected
What is the smell	Alcohol	Alcohol Detected	Alcohol Detected
Is there a contact	Object	Contact established	Contact established

7. CONCLUSION AND FUTURE SCOPE

As per the abstract stated , the system implements all the 5 sense organs of the human body in an integrated manner.

This system, thus provides, an integrated solution for all the 5 senses, which, the existing system lacks. The system has a varied application in today's era of technological advancement. The system can prove to be highly useful in industries where humans cannot intrude into. This would, henceforth, become the primary step towards increasing throughput of the industry without human intervention. The system has a varied implication in various industries, viz. medical , chemical, etc by implementing taste recognizing capability. This system, if gets integrated with the existing BOTs, would replicate humans, which would henceforth replace them in the industries , enhancing the productivity of industries. The system can effectively lessen human labour in adverse conditions, maximizing the profit margin and minimizing the labour cost.

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