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A PARTIAL BIO-MIMICRY OF SPIDER WITH ADDED MODIFICATIONS

Science

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ABSTRACT

Spidy is a multi-legged robot which looks much like a four or six legged arthropod but also has a hidden flight system and the adhesive feature which adds to the utility of the bot in various defense, military or stealth operations.

KEYWORDS

Robotics, Sensor , Machine Learning, Deep Learning, YOLO, NLP, Surveillance

I. INTRODUCTION

The introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper.

II. HEADINGS

Introduction, headings , Goals, Specifications, . Figure and structure of bot, mechanical part explained.

III. GOALS

1. The object recognition feature and computer vision: The spidy would be equipped with an efficient image processing algorithm. So it will be able to make real time object detection and prediction. Feature extraction property will also be added.

2. Speech recognition feature: This feature would be implemented by NLP, convolutional neural networks to establish a more easier way to communicate and operate the bot.

3. Self transforming feature:- The bot should be able to transform itself from a legged robot to a drone like structure when it can no longer rely on the adhesive techniques to scale much larger barriers. And it can also return back to its previous shape(legged state) and use its gaits to travel across any terrain.

4. Travel across all kinds of terrains and obstacles :- Being a legged robot, it has greater passive stability. Every particular complex 3D terrain would correspond to a particular gait which the boy has to implement to traverse it. Therefore 3D mapping of the path is very necessary.

5. The climbing on the walls feature :- This goal is one among the tougher ones. The bot uses a particular adhesive mechanism or sticking property by mimicking a natural process like the gecko tape mechanism or any suction mechanism.

6. Landmine detection and navigation planning :- The bot can detect landmines and find the possible area of their presence, along with identifying and recognizing enemy targets and tracing their location by GPS sensors and therefore, prepares the most suitable and safe path for the armed forces.

7. Poisonous gas sensing :- We can use the e-nose technology to sense variety of gases and thus report any sudden appearance of gases in the air. Also the temperature sensor notes the temperature changes regularly which is also an important parameter.

8. Gesture control feature :- This feature can help improve the stealth of the bot which can be controlled just by gestures from a fair distance and thus the bot works accordingly.

IV. SPECIFICATIONS

1. If the bot is four legged(considering the simplest structure), there shall be 12 actuators or continuous micro servo motors(3 for each leg- coxa ,femur and tibia joints).
2. From the top view, the bot has an octagon like structure, with its legs and the other structures folded inside.
3. A high resolution camera to provide high quality capturing for real time detection and also 3D mapping.
4. Four brushless motors attached on four folding structures that can elongate whenever required and fold whenever they switch from drone mode to the legged mode.
5. The whole weight of the bot is a very important specification because some of the features totally depend on the weight and effective distribution of the weight.
6. The bot has 3D printed parts as the legs which are connected the continuous rotation actuators.
7. The total autonomous system would be controlled by Raspberry Pi, as arduino is meant for lighter projects and would not be suitable for this purpose. The flight controller boards and the servo controlled boards will be chosen as compatible with raspberry Pi.
8. Feature extraction and shape detection (pls refer to the paper)http://ijcsit.com/docs/Volume%206/vol6issue06/ijcsit2015060601.pdf)[1]

Note:- These features are general feature extraction techniques applied on objects(fruits) and can be improved to more accurate methods just by incorporating more sophisticated version of these techniques. Since we are at very initial part of the project so the idea can be further centrified based on what the project needs.

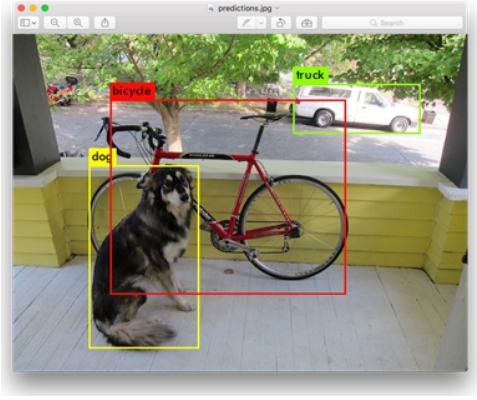
ALGORITHMS PROPOSED

Basically AI can be differentiated into three (or more in future) parts

1. Image Processing: *This part is aimed at making things more noise free. I.e Noise free extraction or recovery of images from the camera. The main motive is that the images from camera should not depend on the resolution. Based on researches several algorithms have been proposed for feature extraction.This image processing is the 1st step of making anything independent. Loosely speaking giving brains to a system and providing it with data and making him to decide itself.Algorithms pertaining to* **noise removal**

a. YOLv3 (you only look once): - Very basic level algorithm for classification of objects from a real video feed. But best among all object detection algorithms(Proved). Capacity 164 frames/s. Detection from weights downloaded from git. https://pjreddie.com/darknet/yolo/.

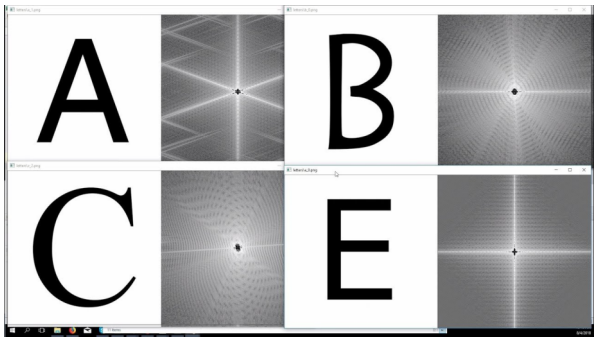
A basic implementation of (Darknet version)



b. Canny edge detection:- This is a very basic way of information retrieval from images. But includes Gaussian noise which can be eradicated using more advanced methods like

Fourier transform of boundaries for edge detection

This implementation involves applying fourier transform on the boundaries of an images. Converting an image from time domain to frequency domain. This implementation is very useful in identification of letters from text as well as for edge detection using noise removal.



The left side is time domain and right side frequency dome. It is very easy to identify these letters as different letters have different patterns of fourier domain signal. A neural network can be trained using this to Achieve utmost accuracy in letters identification.

Now role in edge detection

If we allow a certain frequency(Basically a band pass filter or a high pass filter) to pass through a signal then the fourier transform acts as a edge detector. The picture below justifies that:-

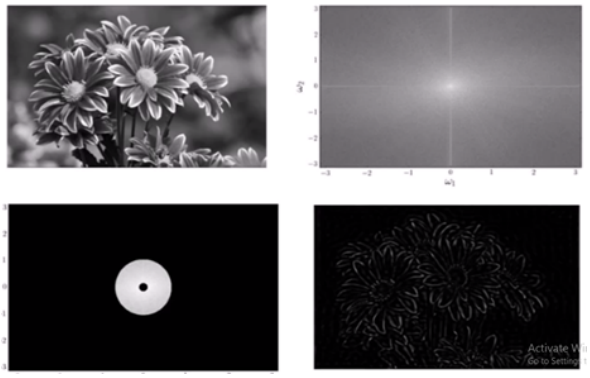


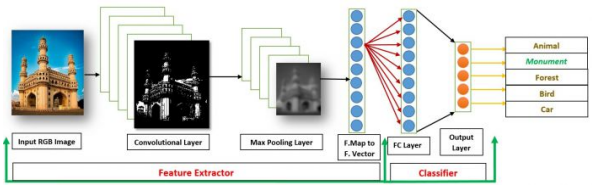
Fig:- This is basically implementation of band pass filter to lower left

A few more Algorithms for noise removal or edge detection for increasing accuracy:-

A. Methods to be used for feature extraction:-
a. DWT(Discrete Wavelet Transform)
b. Fourier transform of boundaries
c. Scale space
d. Recognize boundaries of objects using either centroid contour Distance or Eccentricity and angle code (CCD proved better) using polygon approximation.

Deep neural network implementation using convnets or mobilenet architecture(most preferred)

For this system we will be using deep dense convolutional neural networks fully connected . For activation ReLu activation layer



Then adjusting the drop outs according to the demand of this model we will be able to attain a best possible accuracy.A pooling layer and finally a fully connected vanilla neural network. For this application to make it more portable we will be using bluetooth module because of this reason mobilenet architecture proves to be more efficient in this regard.The images can be trained more accurately i.e for increasing the running accuracy various data augmentation techniques can be used which increases the accuracy of understanding the surrounding. **The camera which we will be using will be of the most smaller size for carrying out stealth mode operation with night vision mode also**.The image processing part will play a great role in this operation . Firstly video captioning into frames and then edge detection using canny edge detection or most preferably fourier transform of boundaries. Followed by contour detection using polygon approximation. Various opencv modules will be used in this process like edge detection ,background extraction as well as bounding box algorithm for YOLOv3 can also be used for detection of specific types of weapons. This data will be fed to a server to which it is connected which will dynamically create a message alarm for the armed forces and can also pass on specific informations without the need for a army official to keep an eye on the monitor all the time. T**his will be a fully autonomous as well as independent and self reliable bot which can withstand many harsh applications that can be tested for and trained accordingly.**

Looking into a secondary part of the project(An unimagined aspect)……..

NLP(Natural Language Processing) plays a great role for making this independent and fully autonomous. The bot will be able to hear all the information and discussions of enemy and interpret them using speech recognition in any of the languages,**Keep a note of the hearings and pass on the relevant information or notes based on a defined set of dictionary keywords(Like war, missile etc….) to army along the GPS location** .This process is still under progress as it is a secondary part to give the bot much freedom for carrying out any application in enemy territory.

Techniques to be used:-

1. Character Embedding CNN for sentiment analysis i.e concluding the findings to be positive or negative.[2]
2. Using Word2vec or Glove model for text generation

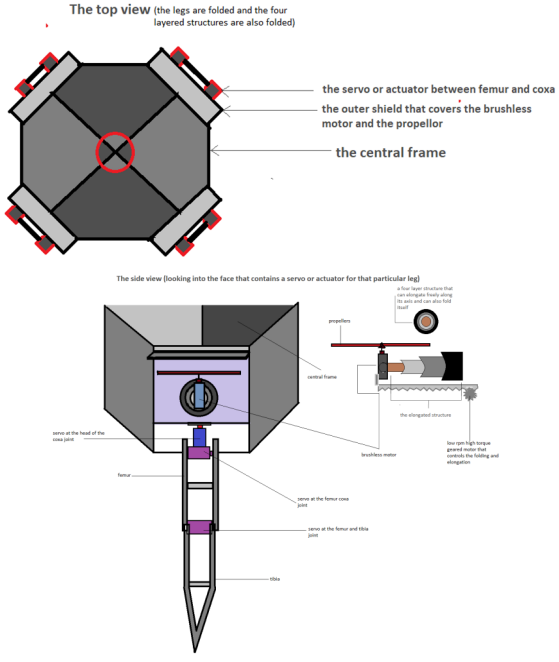
A very important aspect for stealth operation(Self destruction feature)

The entire body of the bot will be covered with touch sensors. In the enemy territory if anyone gets hold of the bot , more precisely touches it . It will explode within 30 s. This feature is incorporated to keep the technology hidden from any foreign nation.

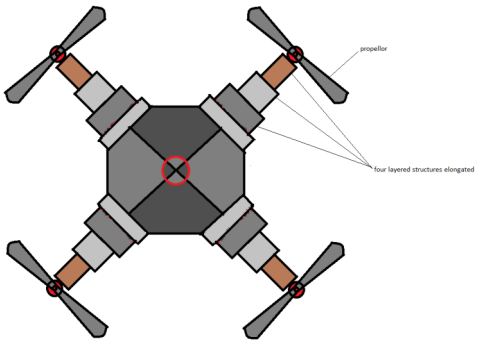
Algorithm for Localization and mapping

SLAM(Simultaneous Localization and Mapping) :- This algorithm accounts for the most common in self driving cars. Most trusted algorithm for remembering the path traversed as well as making a lane traversal view of the entire path and the surrounding. This is why it is called as simultaneous localization and mapping . The map can be viewed in the server in mobile phone only due to the use of bluetooth module.

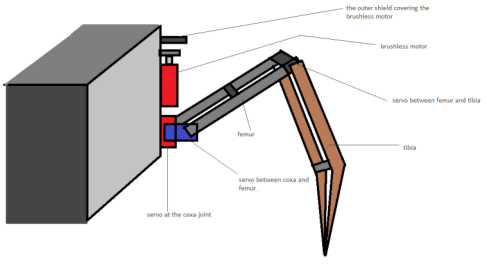
V. Figure and structure of the bot



Top view :- (when the four layered structures are elongated to transform itself to a quadcopter)



Side view: (focussing on one of the legs)



VI. MECHANICAL PART EXPLAINED

I. THE STRUCTURE OF THE BOT :-

(looking into the mechanical aspects of the bot)

This bot has multi-legged mobility that would consist of 8 legs or 6 legs as it would provide passive stability to the bot to keep itself upright in any terrain. The servos or the actuators should be as small as possible(2cm*2cm*1cm). The spidy's movement, it's walking styles are all controlled by inverse kinematics, a method that will dynamically generate the servo angles for a specific feet position. The uniqueness of the bot is defined by the climbing feature of the bot. This would be the most challenging part. The methods that can be used are to install any means of suction which would help it stick to a surface or to use the gecko tape mechanism that uses electrostatic force of attraction by mimicking the sticking mechanism of gecko's feet. This climbing feature of spidy would help it to cross any type of barrier or obstacle (obviously upto a certain height limit). But this would increase the stealth feature which would help it to creep into places, to climb walls, and gather information.

A major challenge:- The property that would be most difficult to manage is the weight of the bot. In this case, it has to managed very effectively and under a limit to make that climbing feature possible. The servos , the servo controllers, the microcontroller, the power supply, and ultimately the framework has to chosen very carefully and as small as possible.

Advanced improvements (if the initial structure of the bot is ready):-

The bot will have a hidden flight system, or the capability to fold its legs, and bring out it's propellers , just like a self transforming system from a multi legged mobility to drone-like mobility. This system is very difficult to achieve as the weight issue must be kept in mind but the advantage is that if this bot has an installed flight system in it then it can cross any height barriers(which was a limit in case of climbing).

Another aspect, which might look small, but is highly significant, that is the reduction of noise that the electronic parts , servos and propellers will make. The bot should be as efficient as it can be and silently carry out its movements and make the least noise. There are many passive techniques which can be applied to experiment on this. Thus , the stealth feature would increase.

REFERENCES

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[2]. Xiang Zhang ,Junbo Zhao ,Yann LeCun for Character-level Convolutional Networks for Text Classification