Smart Suitcase Implementation Using Fuzzy Logic and Deep Learning

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ABSTRACT

This paper proposes a real-time control application using deep learning and fuzzy controller to create a smart suitcase. This device is a mobile robot that automatically follows its owner with the ability to avoid obstacles on its way. The deep learning model used in this project is based on the efficient technique and state-of-the-art object detection algorithm – Mobilenet-SSD convolutional neural network. The fuzzy logic controller with logical if-then rules forms an effective automatic control strategy. This paper presents a proof of concept illustrating the integration of fuzzy controller with real-time object detection and tracking using deep learning.

MODEL

A carry-on suitcase model is designed with four wheels, two of them are controlled by motors. A Raspberry Pi 3 B+ is responsible for owner detection, which is a logo, for tracking with an Intel Movidius Neural Compute Stick. An ARM STM32F407 microcontroller is used to control the robot to follow its owner and stimultaneously avoid obstacles. SPI protocol is implemented for communication between them.

METHODS

A. *Raspberry Pi 3 B+:* Deep learning neural network model for object detection

Dataset is created using taken pictures of the specified logo with the help of data augmentation. Positions of the objects are labelled and saved as XML files in default PASCAL VOC format. Two classes are defined in order to classify the proposed object and background respectively. Cross-validation technique is applied in creating Lightning Memory-Mapped Database (LMDB). The training phase takes place on Google Colaboratory to make use of the computational power of GPU Tesla K40 supported by Google Corporation.

B. ARM

1) *Fuzzy for owner following:* takes the inputs from owner detecting result to compute two outputs for the difference in the two motors' PWM.

2) *Fuzzy for obstacle avoidance:* takes the calculated angle from the bubble rebound algorithm together with current PWM of the two motors to compute two outputs for the difference in the two motors' PWM.

RESULTS

The autonomous suitcase is tested with both indoor and outdoor environment. It has proved to be able to move smoothly in real-time owner tracking and obstacle avoidance. The recorded video is available at https://bit.ly/2xwQP4O.

The training phase gains 92% accuracy in logo detection. Failure cases are found in low-light environment. The detection speed is around 15-18fps, which allows the Raspberry Pi to transfer data to ARM with the sample rate 100ms. Fuzzy controllers successfully produce desired outcomes to control the robot to follow its owner and avoid obstacles.

The suitcase model uses only low-cost devices

CONCLUSION

The approach in this paper has provided a practical application by combining machine learning and fuzzy controller theory. Things become easier for engineers to make real robots in industry with basic principles and low-cost electrical components.