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Smart Advertising Robot with Data Analytics Using Machine Vision

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Abstract: Conventional advertisement methods have the drawback of targeting inappropriate customer segments. A Smart Advertising Robot (SMADBOT) is proposed, aims to improve the effectiveness of advertising through targeted advertising. SMADBOT is a robot implemented with digital display which provides targeted advertisements through data analytics using data obtained from machine vision. Microsoft Cognitive Services is used to predict emotion, gender and age group of people without the need of a self-trained model. Microsoft Power BI is used to classified consumers into various groups to achieve effective targeted advertising. Robot Operating System (ROS) is used as a framework to integrate data from different sensors to perform autonomous navigation. Several metrics were used to evaluate the performance of SMADBOT including age, emotion prediction errors and stopping accuracy. Emotion prediction achieved a mean accuracy of 94% and had a navigation accuracy of 5.51cm in error. SMADBOT was deployed in real environment to further validate and test proposed system, where 184 face counts were collected after a 3-hour autonomous navigation. Data collected were successfully classified into various customer segments for effective targeted advertising.

Keywords: Advertising, Autonomous Navigation, Artificial Intelligence, Face Recognition.

1. INTRODUCTION

Advertising is crucial to bridging business owners and consumers. Conventional advertisement methods use mass media (TV, newspapers and radio) to promote product messages to as much audience as possible without the consideration of demographic and consumers preferences. These often leads to failure in targeting the appropriate market segments and low return of investment in marketing. In recent years, the field of robotics, machine vision and artificial intelligent have advanced, which bring robots into human daily lives, help solving various problem and completing tasks alongside with humans. There is also an increasing social acceptance of robots into human lives. Hence, a Smart Advertising Robot (SMADBOT) with targeted advertising using data analytics is proposed to overcome the drawbacks of conventional advertising methods. The rest of the article is organized as follows: Section 2 discuss about related works done in the past. Section 3 shows the system overview of SMADBOT. Result and discussion are presented in section 4. Section 5 concludes this article with contribution of this research and suggestions for future researchers regarding targeted advertisement.

2. RELATED WORKS

2.1 Targeted Advertising

Targeted advertising defines advertisement shown to a person is targeted by advertisers based on the gender, age and emotion. There different methods in achieving targeted advertising, where some companies use electronic devices of consumers which are connected to specific networks at various locations as a targeted advertising platform [1] while some use location-aware system like Bluetooth to detect location of customer and their behavior for advertisement purpose [2]. Some existing billboards or screens come with hidden miniature cameras. Cameras installed are used for age and gender recognition and to show relevant advertisement. According to [3], targeted advertisement is preferable than non-targeted advertisement.

2.2 Advertisement analytics using Face Processing

Face processing for emotion, gender and age predictions has becoming popular among researcher and big companies. There is face-based signage interactive system which uses users' mobile phones to detect and recognize face [4]. The data collected through mobile phones is used to broadcast targeted advertisements and used to evaluate the effectiveness of advertisement [5].

2.3 Robot Navigation

[6] suggest Gmapping to be the most robust 2D SLAM. While Cartographer used by SMARBOT is an efficient method of acquiring 2D floor plan to be used for robot navigation according to [7]. Robots already available in the market such as Beam Telepresence Robot uses differential robot base and simple mounting screen for telepresence purpose [8]. However, the robot does not have autonomous navigation capability. SMADBOT proposed in this article is an autonomous robot which can be in shopping malls and event venues, providing better targeted advertising service using machine vision and proactively approaching potential customers to delivery advertising messages.

3. SMART ADVERTISING ROBOT (SMADBOT)

3.1 Software

The software of SMADBOT consist of 5 parts (Figure 1), which includes Microsoft Universal Windows Platform Apps, Microsoft Cognitive Services, Robot Operating System, Microsoft SQL Azure, and Microsoft Power BI.

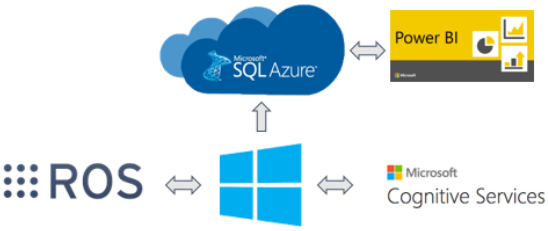

Figure 1. Software system overview

3.1.1 Microsoft Universal Windows Platform App

The initial design of the application consisted of a single page for motion detection, camera stream display, and targeted advertising. Based on user feedbacks, a robot character is created as shown in Figure 2 to have element of entertainment to catch people's attention. Age prediction and gender prediction were added to enhance user experiences. The final UI and UX was a 3-panel view (Figure 2).

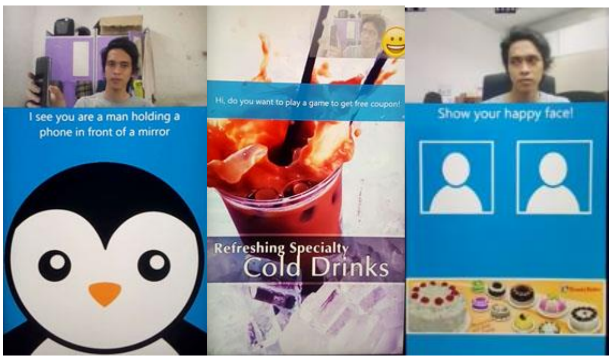

Figure 2. 3 Page of User Interface Used.

The first panel comes with a character like face and have speech synthesizer talking to the user. It will deliver what it recognizes, including user's predicted age and gender.

The second panel shows targeted advertisement, where after a while it will pop-up to ask whether the user want to play game to claim vouchers or discounts for related advertisement.

The third panel will ask user to show 3 emotions to complete the game. The game then will pop-up a QR-code where users use their phone to scan the code to claim promotion vouchers.

3.1.2 Microsoft Cognitive Services

SMADBOT utilized Microsoft Cognitive Services which comes with well-trained model for machine vision. This avoids the need to collect huge amount of dataset for model training which is time consuming. Visual Studio is used for app development where Vision, Emotion, and Face Application Programming Interface (API) are provided and can be implemented with ease. Test runs of the application were carried out as shown in Figure 3.

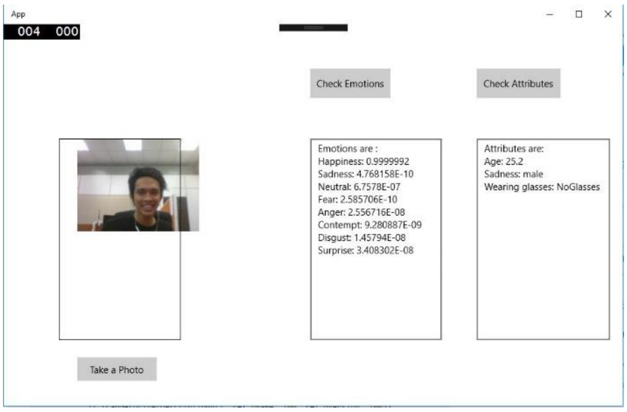

Figure 3. Microsoft Cognitive Services Test App

Vision processing is the core function of SMADBOT. To select which advertisement to display, the system need to recognize the target group. The system will implement Microsoft Cognitive Services to process image and classify a person into categories like age group, gender, and interest. Vision, emotion and face APIs are integrated (Figure 4) to deliver targeted advertising feature of SMADBOT.

Figure 4. Smart Advertising Robot Vision Processing

3.1.3 Robot Operating System (ROS)

ROS is used for navigation part of SMADBOT. It moves based on pre-plotted paths. ROS runs on Linux based computer and the ROS applications communicate using socket programming.

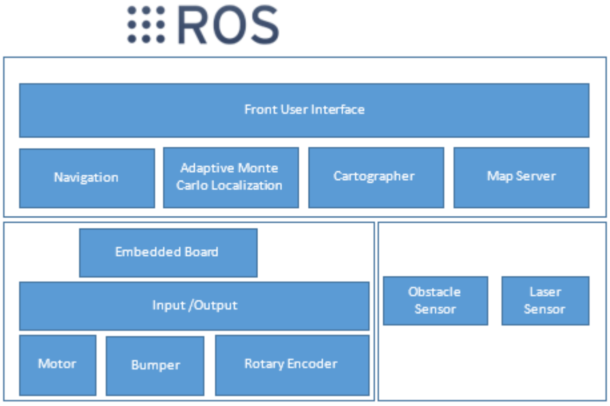

Figure 5. ROS System Overview

A ROS navigation component (Figure 5) was written to perform Bezier curve and straight path movements of SMADBOT. The input and output of the robot such as motor, bumper and encoder are handle by embedded board that communicates with the Linux based computer through USB interface. Obstacle sensors communicates using serial communication and laser sensor communicates with the computer through TCP/IP.

SMADBOT uses NavWix X for high level navigation planning. NavWix X features Block Diagram based Action Programming. Navigation planning is done by first obtain a 2D-map through laser scanning (Figure 6) and then perform path planning tasks as shown in Figure 7.

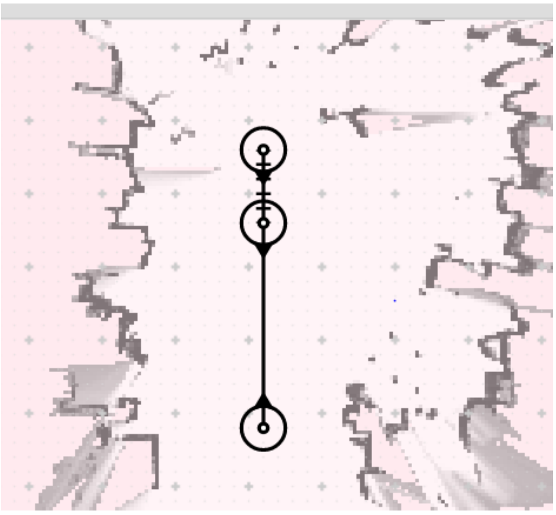

Figure 6. NavWix X Mapping and Map Plot

An example task is as follows (Figure 7): 1. Move from one station in the map, to the next station based on route plot in the map. 2. After 30 seconds, it will move to the initial station then prompt whether the user want to stop the task or not within 5 seconds. 3. If there is no input it will repeat the task again.

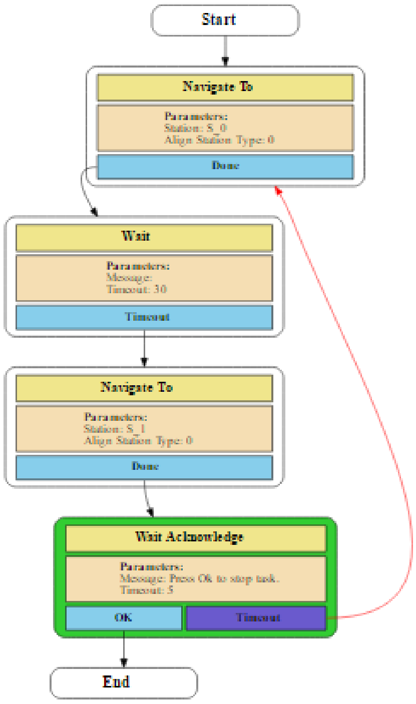

Figure 7. NavWixX Task Template

3.1.4 Microsoft Azure and Power BI

Data analytics and charting are done in Microsoft Power BI by linking real time data in SQL cloud database of Microsoft Azure. Microsoft Power BI let user to show their own chart style and analytics. Demographic data charting of people interacting with SMADBOT is used to let advertisers analyze the effectiveness of their advertisement. Power BI can be access in the cloud as well as local window application, which is suitable for mobile robot application like SMADBOT.

3.2 Hardware

The hardware of the SMADBOT consists of 3 parts which is robot base, the monitor stands and the monitor itself. The robot base is the one responsible to make the robot moves around. It consists of DC brushless motor, 24VDC lead acid battery, main boards, encoder, and an on-off switch (Figure 8). Sponge bumper is installed for safety purpose. A Linux PC which runs ROS is installed on the robot base to process all the sensor data and gives appropriate command to the motors. Aluminum profiles are used for easy assembly and dismantle process for the ease of transportation.

The monitor is setup using a LCD Bracket monitor which has pre-fitted hole for easy assembly and simple monitor angle adjustment. The LCD bracket can easily be rotated for the monitor work in portrait and landscape modes to suits different needs. SMADBOT was first designed using Computer Aided Design (CAD) software (Figure 9) before the hardware fabrication is carried out.

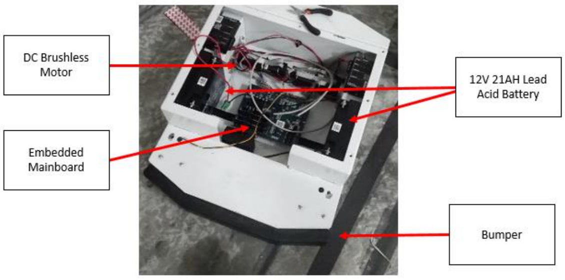

Figure 8. Robot Base Assembly

Figure 9. SMADBOT CAD Design

The robot is equipped with Pepperl-Fuchs R2000 2D Laser Sensor for autonomous navigation. Obstacle detection using Pepperl-Fuchs R2100 Multi-Ray LED Scanner. C920 HD Logitech Webcam is used to perform its vision processing function. Figure 10 shows the actual hardware of SMADBOT.

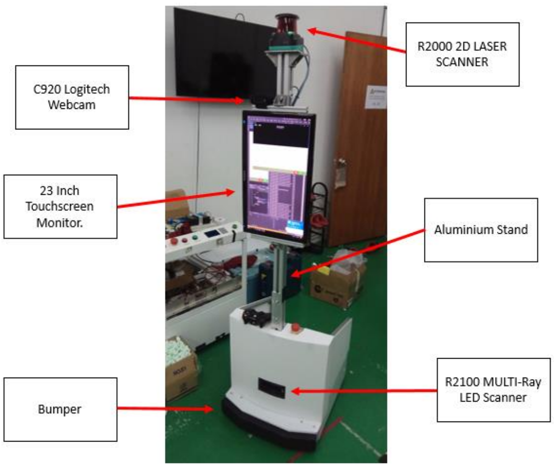

Figure 10. Hardware of SMADBOT

4. RESULTS AND DISCUSSION

4.1 Vision Processing

Age and gender predictions as shown in Figure 11 were handle by Face API. Face detection using local face tracker was first carried out before sending the face image to the Microsoft Cognitive Services. This reduces the need to call for APIs in Microsoft Cognitive Services where human face is absent.

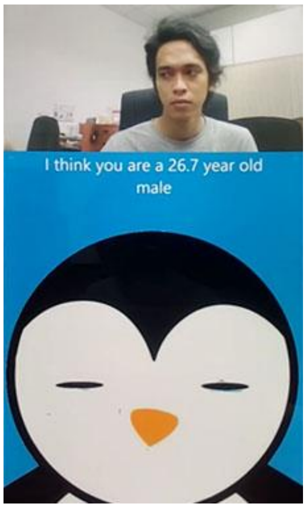

Figure 11. Age Prediction User Interface

Accuracy of the prediction of age was tested using a single subject. Predictions were carried out for subject standing 1 and 2 meters away from the camera. Experiments were repeated for 10 times for each distance. The error of prediction is plotted as shown in Figure 12.

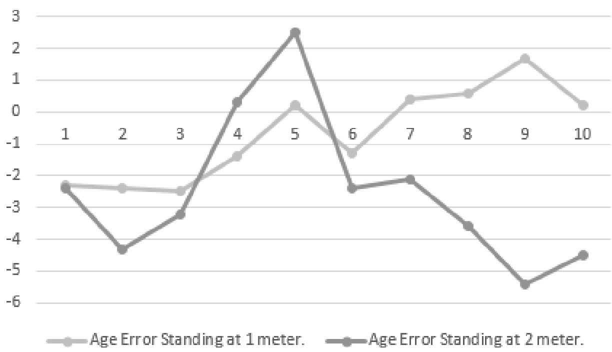

Figure 12. Age Prediction Error for 10 times prediction

From the error plotted, the performance of the prediction is affected by the distance. The error value was higher when the subject stands further from the robot. This may be due to reduced resolution and data available for face processing.

4.2 Emotion Prediction Result

For emotion prediction, the subject was told to show several types of emotions in Table 1 and the prediction accuracy was recorded. Emotion prediction for each emotion was repeated for 10 times. Figure 13 shows the interface for emotion prediction. The emotion prediction was able to achieve an mean accuracy of 94% across all emotion.

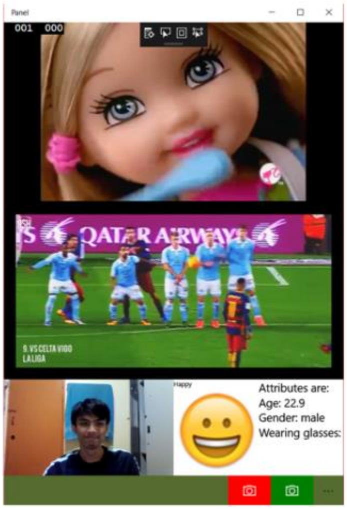

Figure 13. First UI design for emotion prediction

Table 1. Emotion Prediction Accuracy

Emotion Given	Accuracy (%)
Happy	100
Sad	100
Anger	80
Surprised	89
Normal	100

4.3 Navigation

Based on Bezier and straight movement, the SMADBOT is capable of moving around in a shopping mall and stop when obstacle is detected. The navigation was set to loop around at the same place based on plotted path. Using R2100 distance sensor, the robot stops when it detects anything within 1 meter. The holonomic base of SMADBOT has zero turning radius [9], which ease the overall navigation effort.

Before the robot can move around, SMADBOT needs obtain the map of the location. Mapping is done using cartographer library from Google and the map obtained is saved. Using the map, path is plotted based on coordinate in a map. Then, the robot can move around autonomously as shown in Figure 14.

Figure 14. Autonomous movement of SMADBOT.

The navigation accuracy is evaluated by measuring the stopping accuracy using the reference tape on the floor. The navigation error is shown in Figure 15 with a maximum error of 9.4 cm at station 6. The navigation library can re-correct the position of the robot so navigation error will not be accumulated throughout the task which resulted in a mean error of 5.51cm.

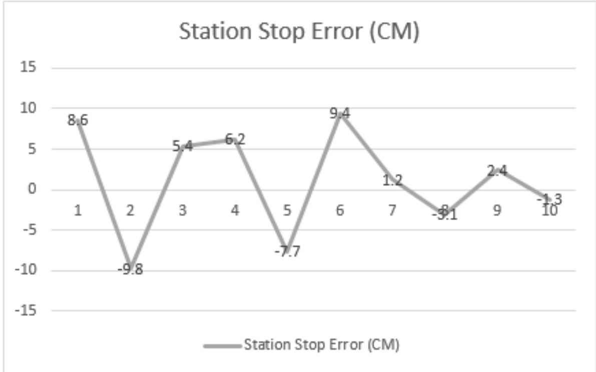

Figure 17. Stopping Accuracy.

4.4 Advertisement Data Analytics

SMADBOT was deployed in real event (Microsoft Imagine Cup Malaysia 2017 in UTP Perak). The robot was moving autonomously for 3 hours' during the event. The robot managed to record 184 face counts. The data includes age group, gender, emotion and advertisements shown.

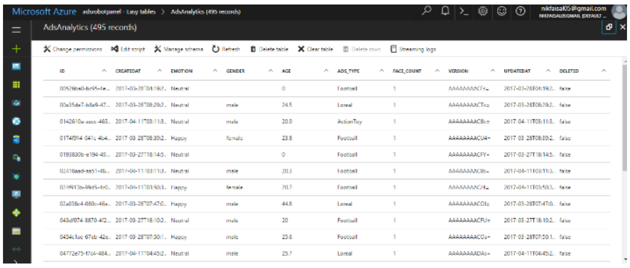

Figure 18. Data collected in SQL table.

Microsoft Power BI was used to perform analytics and show charts. For example, age data was recorded and classified into kids, adult and elders. These can be easily achieved by setting filters inside Microsoft Power BI. For gender chart, the chart is straight forward without the need of filter. Figure 19 shows the data collect was successfully classified into gender and age which is then used for targeted advertising.

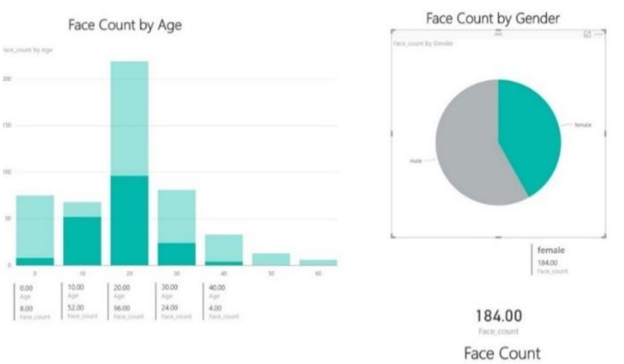

Figure 19. Data analytics using Microsoft Power BI during for data collected

5. CONCLUSION

SMADBOT demonstrates how service robot can be implemented in real environments such as shopping malls and event. The proposed targeted advertising aims to help advertiser to achieve higher return of investment by targeting consumers with appropriate advertisement. SMADBOT utilized Microsoft Cognitive Services to achieve machine vision including age, gender and emotion prediction without the need of training the face processing model. The emotion prediction achieved a mean accuracy of 94%. Microsoft Power BI is used to perform data analytics which consumer demographics can be classified and advertiser can perform targeted advertising effectively. The autonomous navigation of SMADBOT using ROS framework enables advertisements can be delivered to more consumers in different areas in a certain venue. The robot navigation achieved a navigation accuracy of 5.51cm in error. In future, big data analytics can be carried out from the data collected from time to time. Correlations between consumers' demographic and buying behaviors can be analyzed to improve the effectiveness of targeted advertisement system.

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