Emotional BWI Segway Robot

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https:// github.com/sangjinshin/Emotional-BWI-Segbot

1. Abstract

The Building-Wide Intelligence Project's Segway Robot lacked emotions and personality critical in human-robot interaction. In order to make interactions with the robot more human-like and enjoyable, we attempt to give the robot a sense of emotions and personality. The robot is given the ability to keep track of its mood level and to present its current emotion state. By giving the robot emotions and personality we create a system in which humans need to be mindful of the robot's emotions when interacting with them, just like any human-to-human interactions in the real world. When robots are perceived by humans as sentient, introspective beings that must be treated with care, we have taken a step further into developing machines that exhibits intelligence.

2. Introduction

There are growing interests in developing a non-industrial robot that can interact with human beings. These robots would be used as service robots or therapeutic robots to aid humans in homes or healthcare institutions. For these robots to be successfully applied into the real world, robots would need to have consciousness resembling that of human [1]. The robot would need to have enough intelligence to perform tasks effectively and with common sense as any human would. Consequently, an artificial emotional system in robots is necessary for the robots to feel, perceive, and make decisions like humans.

To create a robot that is human-like, we must lose the belief that robots are merely machines that follow user commands or tools that accomplish tasks for us. When we think of human-to-human interactions, we know that a relationship between any two human beings cannot not perfect. It is impossible for any individual to be able to fully comprehend the thoughts of another. However, we gain more and more knowledge about others through series of interactions. There are factors such as personality, trust, and history that play a big role in

assessing a relationship between two humans. A relationship can further grow or otherwise break based on similar or different personalities. Performing actions that affect the level of trust between two people are critical in determining how much either individual is influenced by subsequent interactions. The history of two people's relationship – how long they have known each other and interacted with one another – gives individuals further insights about each other that can affect their decision-making processes.

In this paper, we introduce an exploratory approach to creating an emotional system in the Segway robot that is currently part of the Building-Wide Intelligence Project at the University of Texas at Austin. We wanted to mimic the properties of human-to-human interactions in human-to-robot interactions. Therefore, we quantify the robot's mood level as a double-precision floating point number. We also give the robot a personality by randomizing the thresholds for the robot needs to reach to express various emotion states. The robot's emotions are altered based on the series of interactions between the robot and the human. Through these interactions, concepts of trust and history are brought forth and incorporated into the robot's emotional system.

3. Background and Related Work

A research published by Japanese researchers to IEEE in 2015 involved creating a behavioral-emotional system in which the robot's emotional state changed based on an equation that determined the probability of state transition [2]. The robot first recognized the external situation using its webcam. Next, the robot labeled and calculated the shapes and sizes of the target objects. The robot then created an emotion map based on the visual information that determined the motivation level. Theses motivation levels and other gathered data would be inputted into an equation, and the robot's emotional state would be expressed via its arm or the head.

Another research published by Japanese researchers to IEEE in 1999 involved a subjective evaluation of artificial emotion [3]. An emotional attachment and interactions cannot be measured objectively because the evaluation of emotional intelligence is ultimately a subjective evaluation of intelligence by humans. Modeling emotions and gestures can be difficult as various situations and context must be taken into account. The robot's emotional intelligence was determined based on how much the robots could stimulate humans' affections and the aesthetics

of the robots. The robot was allowed to generate their own goals and motivations rather than humans giving them tasks or goals to accomplish.

```
ppy_threshold = static_cast<float>(rand())/(static_cast<float>(RAND_MAX/(1.1-0.1))); // 0.1 to 1.1, inclusive
d_threshold = (static_cast<float>(rand())/(static_cast<float>(RAND_MAX/(1.1-0.1)))) * -1; // -0.1 to -1.1, inclusive
gry_threshold = sad_threshold - 1.0 - (static_cast<float>(rand())/(static_cast<float>(RAND_MAX/(1.1-0.1)))); // always less than (sad_threshold - 1
```

Fig. 1 Emotions Threshold

```
Emotion determineMoodLevel(bool isCommandFollowed)
{
    // Calculate the change in the current mood level based on isCommandFollowed and percentage of commands followed and unfollowed
    diff_percentage = (static_cast<float>(num_yes)/static_cast<float>(total_num_commands)) - (static_cast<float>(num_no)/static_cast<float>(total_num_commands));
    if (isCommandFollowed)
    {
        if (diff_percentage >= 0.0)
        {
            current_mood_level += (desire_level * diff_percentage);
        }
        else
        {
            current_mood_level -= (desire_level * diff_percentage);
        }
    }
    else
    {
        if (diff_percentage >= 0.0)
        {
            current_mood_level -= (desire_level * diff_percentage);
        }
        else
        {
            current_mood_level += (desire_level * diff_percentage);
        }
    }
```

Fig. 2 Mood-Changing Algorithm

4. Technical Approach

4.1 Overview

This project is an explorative approach to implement a human-to-human interaction in a human-to-robot interaction. The project is implemented using ROS Indigo framework. The ROS package created is named *emotion_driver* and it consists of three nodes *emotion_driver.cpp*, *emotion_info.cpp*, and *emotion_face.cpp*. These three nodes are run in parallel with the *teleop_twist_keyboard* node in the BWI *segbot_bringup* package.

4.2 Implementation

4.2.1 Artificial Personality

The robot is given the ability to keep track of its mood level, *current_mood_level*, with a double-precision floating point number defaulted at 0.0. The robot has four emotions: neutral, happy, sad, and angry (Fig. 1). Each emotion has different thresholds that the robot's mood level must reach before expressing the corresponding emotion. These thresholds are randomly

generated using the random generator in the C++ standard library. These randomly generated thresholds represent the personality of the robot. When run across multiple robots, each robot would have differing thresholds for reaching each emotion and thus demonstrate differing personalities as the case with human personalities.

4.2.2 Mood-Changing Algorithm

The robot's emotion state is directly based on the robot's *current_mood_level*. The robot's mood level is affected by the *desire_level* of each command and *diff_percentage*, or trust level, of the robot on the human user (Fig. 2). The interaction between the robot and the human begins with the robot randomly choosing to give one of four commands -- move forward, move backward, turn left, and turn right -- to the user using the random generator in the C++ standard library. Each command is given a random weight value 0.0 to 1.0, inclusive. This weight value, *desire_level*, represents the level of importance the robot places on the task. The trust level, *diff_percentage*, is the difference of percentage of commands followed by the user and the percentage of commands not followed by the user. Consequently, the trust level is positive when the user has followed more commands than he/she has not followed, and negative when the user has not followed more commands than he/she has followed. When the trust level is positive, the robot's *current_mood_level* increases by the product of *desire_level* and the *diff_percentage* (trust level). When the trust level is negative, the robot's *current_mood_level* decreases by the product of *desire_level* and the *diff_percentage* (trust level).

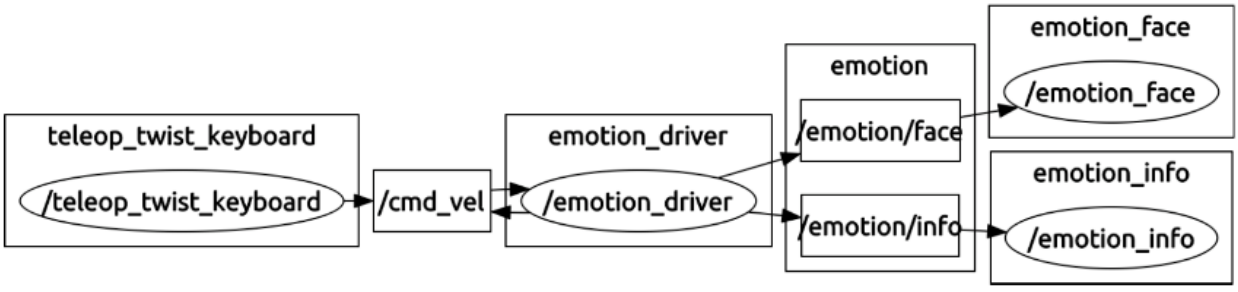

Fig. 3 RQT Graph of Emotional BWI Segway Robot

4.3 ROS Package

4.3.1 *emotion_driver*

The *emotion_driver* is the main driver of the emotional system implemented for the BWI Segway robot. The robot's emotional system cycles as follows (Fig. 3):

1. Robot gives movement command.
2. Wait until user input, and linear and angular data from cmd_vel has been received.
3. Determine if user followed command.
4. Calculate the change in *current_mood_level* and determine new emotion.
5. Publish variable data to *emotion_info* node, and publish ASCII art face to *emotion_face* node.
6. Repeat.

4.3.2 *emotion_info*

The *emotion_info* node displays all the variable information, such as the values of emotion thresholds, *current_mood_level*, *desire_level*, and *diff_percentage*. This node is for debugging and testing purposes only. In an actual experimental setting, the user would not know the *desire_level* the robot has placed on the impending command and the current trust level of the robot. Therefore, the user would have to be mindful about the actions he/she takes that will directly reflect in any changes to the robot's emotion state, demonstrating how human-to-human interactions work in reality.

4.3.3 *emotion_face*

The *emotion_face* node expresses the emotion state of the robot. It portrays the robot's facial expressions using ASCII art.

5. Evaluations

There are numerous advantages and disadvantages to the implementation of emotional intelligence presented in this paper.

We developed an emotional system where a robot is given a distinct personality like a human. With several, altering variables that affect the robot's *current_mood_level*, it is very difficult to know how the robot's mood may or may not change with the impending command.

This way, the interaction between the robot and the user is unpredictable. It has also created a need for compromise between what the robot wants to do and what the user wants to do.

There are definitely imperfections to the emotional system implemented in this project. The randomly generated variables that mostly represents the emotional system are pseudorandom. Thus, they may not be adequate in representing personality or emotions like those of humans. The Mood-changing algorithm can be put into questioning as well. While the algorithm takes into account a few properties of human-to-human interaction such as probability, personality, and trust, it only mimics a simple basis of human-to-human interaction and lacks complexity.

6. Future Work

The ultimate goal of creating an artificial emotional system is to form a clear, enjoyable communication between humans and robots. In relevance to the BWI Segway robot, LED lights can be installed to vividly express the robot's current emotion state. The emotional system in this project does not take into account its surroundings. An improvement for this issue would be to incorporate the 2D costmap of the building so that robot does not give movement commands that cannot be followed due to possibility of collision. This project's attempt to create an emotional system for the BWI Segway robot is still elementary. However, additional features and improvements can result in some interesting interactions between humans and robots in the future.

References

[1] J. McCarthy, "Making robots conscious of their mental states," In Muggleton S (Eds.), Machine intelligence, Oxford: Oxford University Press, pp. 3-17, 1996.

[2] Jitviriya, W., M. Koike, and E. Hayashi. "Behavior Selection System Based on Emotional Variations." Proceedings of the 24th IEEE International Symposium on Robot and Human Interactive Communication, 462-467.

[3] Shibata, T., T. Tashima, and K. Tanie. "Emergence of Emotional Behavior through Physical Interaction between Human and Robot." Proceedings 1999 IEEE International Conference on Robotics and Automation, 2868-2873.