SUSI GENE: a portable robot as venting, recording and sharing tool for improving mental health condition

Mental health condition is a major challenge throughout the world, yet mental health services in many countries are struggling to meet such needs. Studies have shown innovative intervention can have positive impacts on patients' mental health conditions. This paper presents SUSI GENE, an egg-shaped portable robot, designed for people with mood disorders, including major depressive disorder, bipolar disorder, etc. Through interactions, SUSI GENE attempts to help patients increase their self-awarenesses, vent their emotions, face their inner conflicts, and reappraise their problems in a less negative approach.

CCS Concepts: • **Human-centered computing** → **User interface design**; *Sound-based input / output*; • **Social and professional topics** → **People with disabilities**; • **Hardware** → *PCB design and layout*; • **Applied computing** → **Consumer health**.

Additional Key Words and Phrases: datasets, neural networks, gaze detection, text tagging

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1 INTRODUCTION

1.1 What is susi gene

SUSI GENE is an interactive emotion assistant. It consists of a tangible egg-shaped robot along with an interface. The robot receives vocal inputs from a user; the mobile phone converts that radio to text for natural language processing; while the interface accordingly generates a virtual creature for the user as well as documents these data.

Past research indicated that people with mood disorders demonstrate overall satisfaction with the usage of mobile technology to increase their mental well-being.[5] A large variety of products and research prototypes have made it possible for people to self-monitor their mental conditions, but most of these systems are designed as apps on mobile devices, and thus do not involves tangible interactions.

SUSI GENE also incorporates recording capabilities and requires some operations on mobile devices. However, it has several significant differences. We designed SUSI GENE as an egg-shaped portable robot aims to provide the user a more intuitive experience while sharing his or her stories and feelings.

1.2 How susi gene works

For our current prototype, the user is expected to talk directly to the egg and hold the button that corresponding to his or her current emotion. There are eight emotions, each of them is corresponding to a button with a unique shape. After that, the user needs to place the egg on the back of a mobile device and, through the usage of Near-Field-Communication(NFC) technology, wait for the device pairs with the robot to receive and interpret the piece of audio and vibrates as a feedback

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signal. During that time, the radio is converted to text for natural language processing(NLP), the text would be split into several keywords. The selected keywords would be analyzed in reference to the HowNet and NTUSD sentiment lexicon, and the "emotion gene" is therefore finalized. After a brief vibration, a creature would hatch out and shown on the screen. The picture of the generated creature and the radio of his or her words will be saved for later usage. The user can not only review those past experiences but also share them to his or her friends, family members, or professional counsellors.

The interactive process imitates the natural hatching of the oviparity animals. Our design assumption is that the process of the young break through its shell is especially inspiring and may bring positive impact on the level of enjoyment.[3]

FIGURE

It is often found that people noticed they were holding some negative emotions and at the same time, felt bad for this fact and therefore were more prone to negative emotions. We wish to convey the idea that all emotions can hatch out lovely creatures and thus guide the users away from making value judgment about different emotions.

We select eight emotions which are tranquil, contented, joyful, excited, fatigued, upset, anxious and angry as the identification bases, and inspired by Hanada,[1] we arrange them from two dimensions: pleasantness and arousal level. Based on previous studies in color psychology,[6] we assigned specific shapes and colors to each emotion to facilitate identification. The two emotions with similar arousal level, such as tranquil and fatigued, share a basic pattern but varies in colors and edges. The pattern demonstrate emotions that are considered relatively pleasureless have sharped edges and in darker colors, whereas the pattern presented other emotions have rounded edges and in brighter colors.

These shapes and colors also become the bases for creature generation. The eight emotions respectively matches eight kinds of creatures. In general, the emotions relates to pleasure are either represented by plants or warm blood animals, and the emotions relates to displeasure are visualized as fungus and cold blood animals. In this prototype, the kinds of animals along with their basic appearances and backstories are pre-defined (some of the settings are illustrated below), but the additional information provided by the user is supposed to affect how the detailed components finalize. In our future versions, we expect to make the generated creature more unique and personalized by altering more elements of the creature.

- Cacited: Cacited is a cat-like creature. Cacited's ancestor lived in alpine region and that endows his exceptional speed and hunting skill. His eyes and ear would shine after a successful hunting.
- Repgry: Repgry has jagged fins on its cheeks and acicular scales on its body. It lives in desert area and lack of water makes its fins and scales change from soft to hard. Repgry has always been trying to stay closer to water since he worries other animals would avoid him because of his appearance.
- Anxect: Anxect is very small—about 4 millimeter long, and so is his heart. Thus, Anxect's pulse may suddenly race, and he has to vibrate his wings quickly to reduce the symptoms. During that process, he might unexpectedly finish a long journey.
- Upsafish: Upsafish is a type of mollusk living in the sea. He has two forms. In normal state, he looks like an octopus, and during cloudy days, he would grow into a whale tail and shows some spots on his skins until the sun returns.

2 BACKGROUND

Today, mood disorder, including depression, has became the worldwide leading cause of the Years Lived with Disability (YLDs). Many countries have started to pay increased attentions to people's mental health conditions, and a number of plans aimed to make mental health services more accessible have emerged. However, most of these approaches, including one-to-one counseling, are mostly resource-intensive since each patient should be addressed individually.[4]

According to Monroe and Simons' model, the factors causing psychopathology can be basically concluded as diathesis (predisposition/vulnerability) and stress (triggers).[2] The model suggests all individual, no matter having what innate diathesis, has possibility to develop mood disorder under certain amount of stress, and proper react mechanism to the event of stress is the main solution to reduce that possibility. Considering the foreseeable shortage of mental health services, it is of crucial importance to find innovative interventions to help people with mood disorder in all stages, especially when they remain undiagnosed. Based on the interview of 11 subjects who suffer from mental disorder, we locate two situations that most likely cause and even continuously worsen a person's mental health problem, which are:

(1) low-recognition of stress-caused emotion changes
(2) emotion-driven social isolating

Recent research and products provide solutions by replacing the communicatee from human beings to algorithms. However, there is little interactive solution focusing on changing these two mechanisms by guiding the individual to apply new actions to improve their overall mental qualities.

Therefore, we designed SUSI GENE: a robot with tangible interface to help users sharing their stress event and related emotion changes through a gamified process. Our design is based on cognitive-behavioral therapy(CBT), which asks patient to record the process of how their generate a certain emotion, and by doing this, helps patients deconstruct as well as change their previous beliefs toward a more positive mindset.

3 HARDWARE DESIGN

SUSI Gene is an egg-shaped portable robot, its dimensions are 62 mm in diameter and 80 mm in height. Its center of gravity is low, so it can stand on the back of the phone like a tumbler.

The SUSI Gene prototype is comprised of three main hardware components: the main PCB with an Arduino NANO BLE Sense and other necessary components on it, a battery, and a 3D printed shell.

3.1 Main PCB design

The main PCB integrates a mount for Arduino Nano 33 BLE Sense (with headers), a battery connector, 6 individually addressable Warm White RGBW version WS2812B with integrated drivers, connector for vibration motor and NFC coil, and an I2C port for NFC chip communication.

The main PCB schemetic is shown in Fig 1 and its layout is shown in Fig 2.

Also Arduino Nano 33 BLE Sense supports NFC, we cannot drain power from the NFC coil using Arduino itself. It's necessary to add an additional chip to support wireless charging. We decide to use NXP and embedded it on the coil PCB. The communication protocol between NXP and Arduino is I2C.

SUSI Gene is illuminated in RGBW using WS2812B on main PCB which are wrapped inside the 3D printed enclosure to provide the robot's state display as well as full color indicating.

The communications chipset on the Nano 33 BLE Sense can be both a BLE and Bluetooth client and host device. The main communication method between SUSI GENE and your phone is BLE.

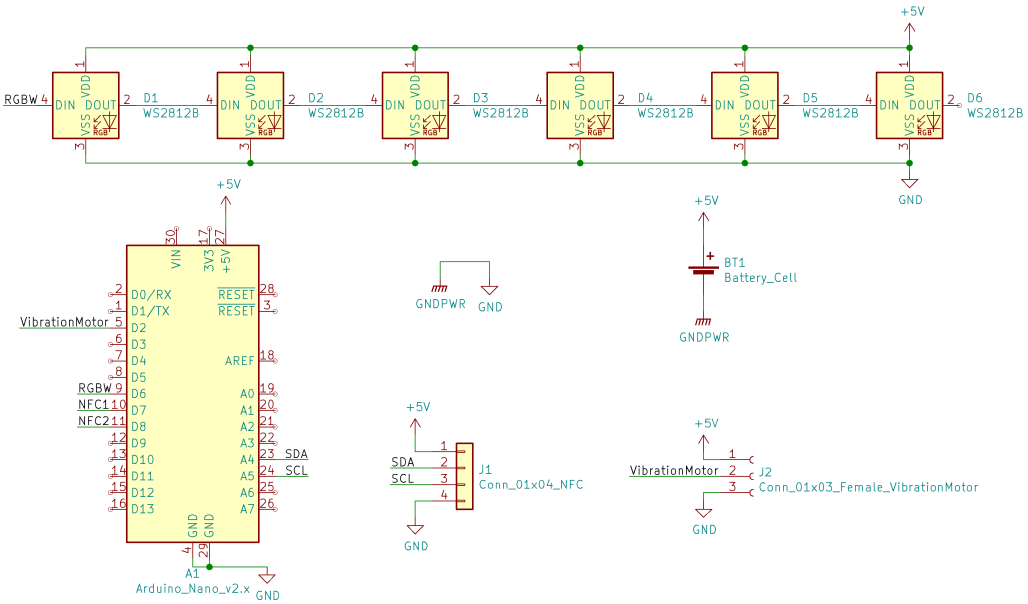

Fig. 1. The main PCB schemetic

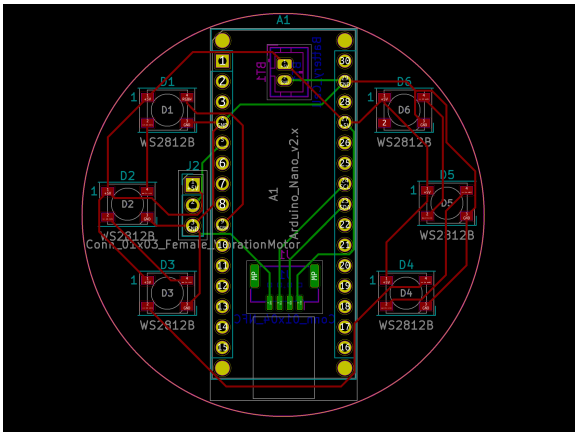

Fig. 2. The main PCB layout

The IMU(LSM9DS1) can detect the movement of SUSI GENE. When the user move or touch the egg, it will vibrate or glomming depending on current feelings.

3.2 Power consumption analysis

SUSI Gene is powered by a 4000mAh 5V battery(3.7V 1S LiPo with boost PCM). Most of the power in the robots are consumed by the LEDs and Arduino. The current draw is approximately 200 mA during typical use. Thus, with a 4000 mAh battery, SUSI Gene is capable of working for about 20 hours without NFC wireless charging. Furthermore, with ultra low power consumption modes of Arduino, it can work longer when enabled.

3.3 NLP solution

One of the most important reason of using Arduino Nano 33 BLE Sense is that it has the ability of Embedded Artificial Intelligence. It is possible to run Edge Computing applications (AI) on Nano 33 BLE Sense using TinyML. We can create our machine learning models using TensorFlow Lite and upload them to it using the Arduino IDE. The microphone(MP34DT05) on board can record your voice imformation. With those feature, we can get voice recognition results with NLP model.

However, the calculate ability of Arduino is too low to run complicate algorithms. After lots of efforts, it can only recognize simple phrases. At last, we decide to use smart phone and its microphone instead. But in the near future, we will integrate NLP process in SUSI GENE itself by using more powerful chip supporting tenserflow or other machine learning algorithms.

3.4 NFC PCB

With NFC tag in the bottom of SUSI GENE, smart phone can recognize it using different UID of NFC tag and begin timing.

If users' smart phone do not have NFC function(like old iphone), we provide an egg nest using NXP CLRC663 plus (High-performance NFC frontends) and connecting with smart phone by BLE.

We use NXP NTA53321G0FTT(NTAG 5 boost: NFC Forum-compliant I2C bridge for tiny devices) as re-programmable NFC forum type 5 tag. It can harvest up to 30 mW energy when used as passive regulated.

NTAG 5 boost should be used for antennas smaller or equal class 6. For larger antennas NTAG 5 link or switch should be used. So in this case, we use NXP NFC Antenna Design Tool to design a class 6 antenna for NTAG 5 boost. The antenna of a "Class 6" design shall be located within a zone defined by a circle of 25mm diameter.

The NFC PCB schemetic is shown in Fig 3 and its layout is shown in Fig 4.

4 DISCUSSION AND FUTURE WORK

In the future, we wish to integrate NLP process in SUSI GENE itself by using more powerful chip supporting tenserflow or other machine learning algorithms.

If we still want to put NLP on smart phone instead of emmbedded system, we can also use nRF52840 rather than Arduino Nano 33 BLE Sense to make the egg smaller and more efficient.

With much more powerful chips, we can make SUSI GENE smaller, more efficient and more portable.

We will find some people who suffer from mood disorders and do some user experiences and field survey. Due to COVID pandamic, we have difficulty in UEX. But one of us suffers bipolar disorder, and she come up with this idea. Another member has major depressive disorder, he trys most functionality of SUSI GENE, and give mostly positive feedback.

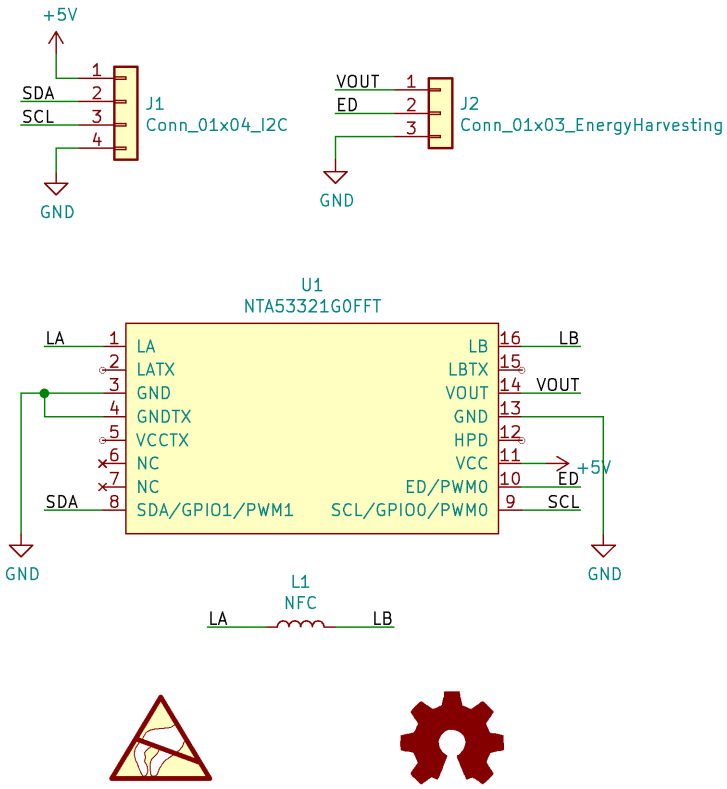

Fig. 3. NFC-PCB schemetic

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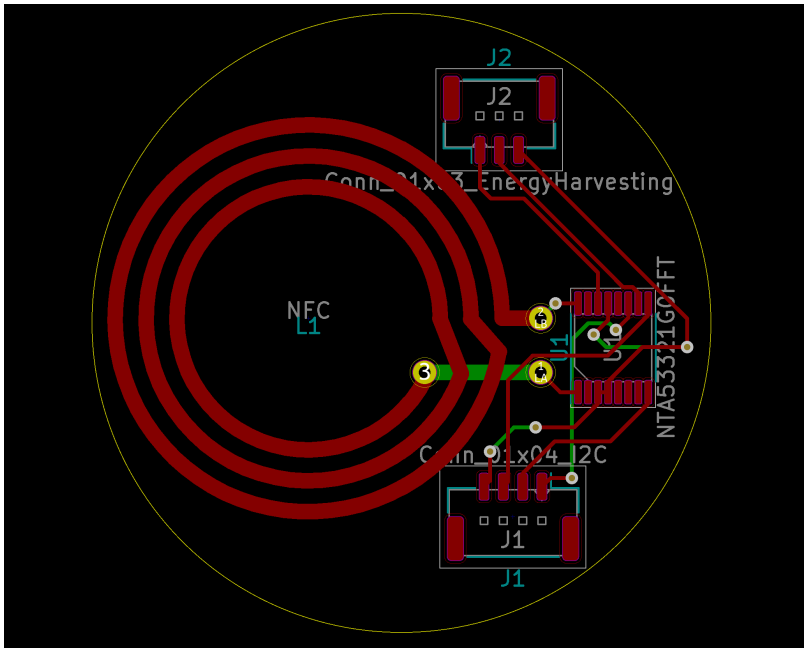

Fig. 4. NFC-PCB layout