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# Design and Implementation of Electroceutical for Depression Treatment

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**ABSTRACT**: The brain is made up of left and right hemispheres, each with distinct functions and an asymmetrical nature. Animal depression occurs when this asymmetry becomes more pronounced, resulting in noticeable abnormal symptoms. By utilizing the brain's functional differences and analyzing brainwave patterns through EEG, it's possible to gauge the extent of asymmetry between the left and right hemispheres. In cases of depression, there are abnormalities found in the anterior frontal lobes. Under normal circumstances, the left frontal lobe exhibits more activity compared to the right. However, in cases of depression, there's a relative decrease in activity in the left frontal lobe and an increase in activity in the right frontal lobe. Higher levels of alpha waves indicate reduced brain activity, revealing a lower activity level in the left frontal lobe of individuals with depression. Conversely, higher levels of beta waves indicate heightened brain activity, suggesting that the right frontal lobe becomes more active than the left, a pattern often seen in depression.In this research, depression's quantified brainwave imbalances were measured using sensors and EEG (electroencephalography). The data was then transmitted through an Android IoT (Internet of Things) app to an IoT server platform conforming to the oneM2M standard.Using the collected EEG data and brainwave imbalance information, an SVM (support vector machine) model was created on the server platform to classify different mental states. This model facilitates early diagnosis and treatment of depression based on the categorized brainwave imbalances. By designing a high-speed data processing algorithm capable of wirelessly measuring and real-time monitoring of brainwaves, a system was developed to diagnose and treat depression. The synchronization of EEG phase via self-stimulation devices and sensors enables real-time diagnosis and treatment of the cerebral cortex. To cater to different diagnostic and treatment needs, EEG sensors and stimulation coils were developed, with the capacity for communication and the addition of extra components when necessary.This system allows real-time monitoring and stimulation therapy on devices like cell phones, ensuring accurate and immediate diagnosis and treatment tailored to the individual's symptoms.

**KEYWORDS:** electroencephalography, IoT, SVM, synch-ronization, Dipression, stimulation

## I. INTRODUCTION

There's a connection between the activity of alpha waves and arousal levels. Research has shown that the left frontal lobe displays greater activity, particularly in the case of violent behavior subjects. Studies on frontal alpha asymmetry have highlighted heightened activity in the left hemisphere compared to the right, which holds implications for mood regulation. Resting EEG patterns also help differentiate patients with and without depressive symptoms. In essence, various studies point to the phenomenon of alpha asymmetry, where alpha waves are more pronounced on the left side than the right, being associated with depression. Especially in the context of treating animal depression, a therapeutic device utilizes monitoring and portability. By applying current pulses through self-stimulation, nerve stimulation energy is converted from the stimulation, utilizing bio-neural energy to boost neural activity. The mechanism behind depression involves genetic factors, monoamine deficiency hypothesis, stress, and dysfunction of the hypothalamus-pituitary-adrenal axis. Genetic variations in the promoter region of the serotonin transporter gene (5-HTTLPR), coupled with stress, can contribute to depression. The noradrenaline-serotonin system has far-reaching effects in the brain, influencing key functions. Enhanced activity of norepinephrine, serotonin, and monoamine

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oxidase, the enzyme that breaks down norepinephrine and serotonin, occurs in the nervous system's synapses, with a 30% increase in brain activity. Depression sees an increase in plasma cortisol, cerebrospinal fluid, and CRH in the hypothalamic-pituitary-adrenal axis. Suppression of CRH secretion by dexamethasone is impaired, and improvement in symptoms due to antidepressants relates to the recovery of the hypothalamus-pituitary-adrenal axis. The influence on neuroendocrine factors is significant, with elevated cortisol inhibiting neural cell proliferation and reducing hippocampal size. Mitochondria play a crucial role as the primary energy source in cells, producing adenosine triphosphate (ATP) via oxidative phosphorylation. Electron transport chain complexes I-V, two electron carriers, coenzyme Q10, and cytochrome C are involved in this process. Mitochondria are pivotal in cellular activities like apoptosis and calcium ion regulation. They're implicated in congenital genetic disorders, aging, type 2 diabetes, neurodegenerative disorders, cardiovascular diseases, and cancer. Synthesis, secretion, and reuptake of neurotransmitters like serotonin and norepinephrine demand substantial energy, linking cellular energy production to depression[1].

## II. MATERIALS AND METHODS

The frontal lobe volume is reduced by 7%, and the subgenual anterior cingulate cortex volume is smaller by 48%, with the anterior cingulate cortex's volume decreased by 32%, indicating frontal cortical volume reduction. In states of rest and simple resting states, there's a diminished activity of left anterior cingulate cortex and anterior frontal cortex[2]. Moreover, bilateral anterior cingulate cortices' activity is lowered. Serotonin is a crucial monoamine linked to psychiatric disorders and pathologies.

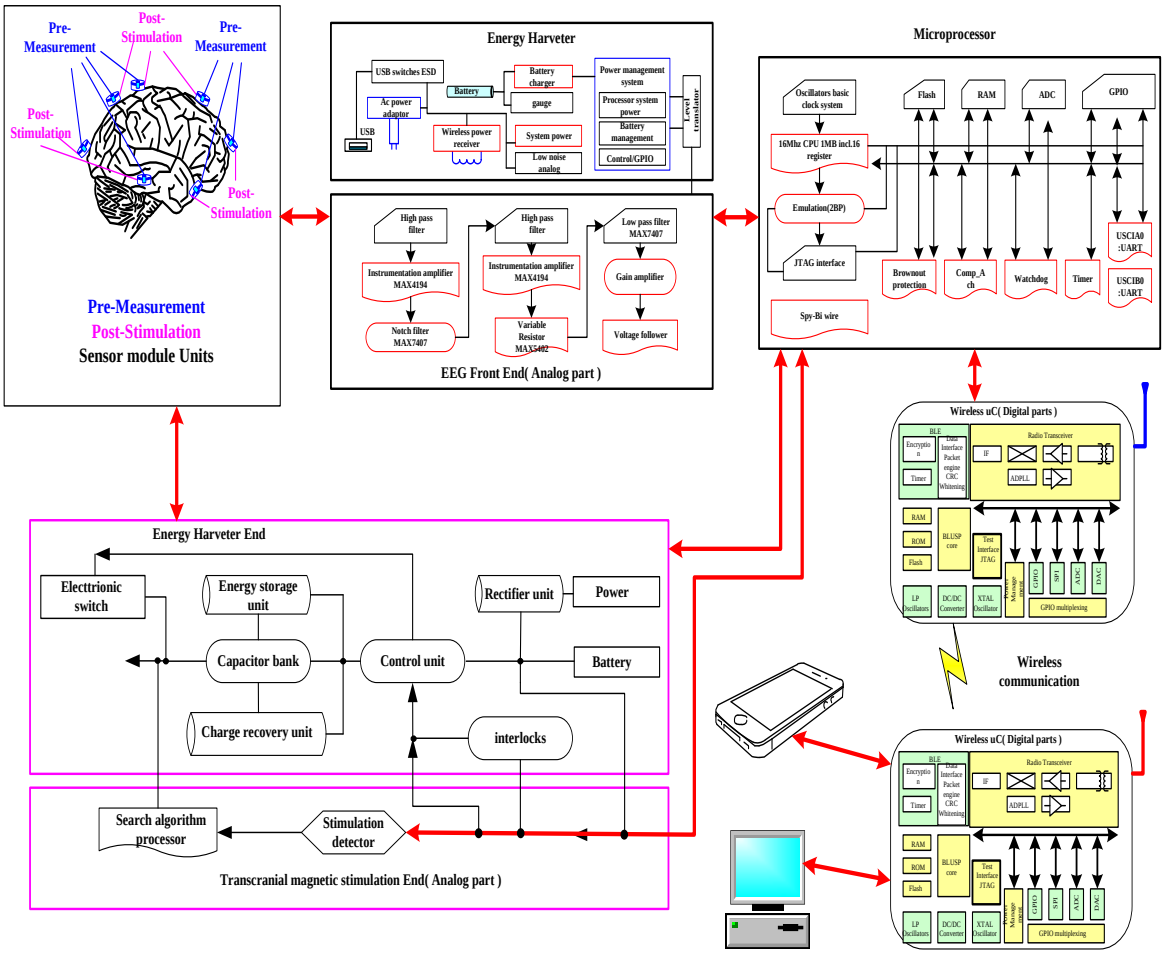


Figure 1 depicts the overall configuration of the proposed animal depression therapy device.

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Decreased serotonin levels are associated with suicidal tendencies. To address these issues, the present invention proposes a solution in the form of utilizing self-stimulation therapy, particularly electromagnetic pulses, for treating animal depression and similar conditions. This involves stimulating the cranial nerves through these pulses[3]. The invention aims to prevent brain nerve damage by utilizing bio-neural energy converted through neural stimulation.Brainwave measurements are analyzed using the International 10-20 system and MCN (Modified Combinatorial Nomenclature) electrode placement method. Brainwave extraction involves three signal processing methods: preprocessing (ICA, Band Pass Filtering, Notch Filtering), feature extraction (PCA, power spectrum, autoregressive model), and classification[4]. Depression-related brainwave features include asymmetry between left and right frontal lobes' brainwaves, where the left frontal lobe associates with positive thoughts and the right with negative ones[5]. In cases of depression, alpha waves increase in the left frontal lobe, and beta waves increase in the right frontal lobe, with worsening symptoms leading to exacerbated asymmetry[6].

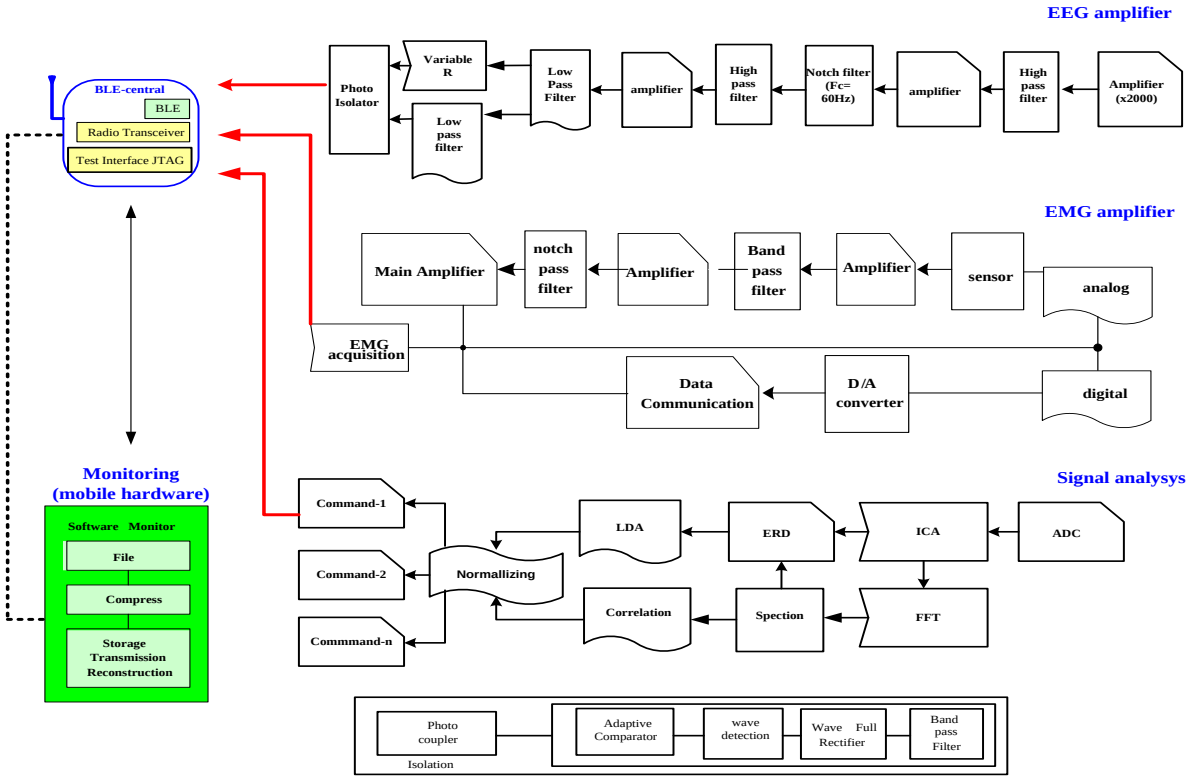


Fig. 2 Amplification, signal analysis, analysis by abnormal measurement category, and variation in amplitude and frequency of measured brainwave data

Cell phones allow respondents to answer surveys, which are then sent in XML document format to a server[7]. The server stores questionnaire results and medical history in a database. XML documents for communication consist of a document indicating the doctor's login information and another for patient information. The measurement module acquires brainwaves in real-time as raw data and monitors the data, receiving up to 32 channels with 250 data points per second. Data is processed through a high-speed algorithm, and channel-specific raw data is stored in separate stacks. The FFT module analyzes signals by selecting channels and conducting FFT analysis to examine frequency.The module's results determine depression scores, and upon completing the treatment, the settings for the therapy device are configured and saved. The configured file is stored on a USB drive and inserted into the therapy device to initiate its operation.

**System composition and principal**

Figure 1 illustrates the comprehensive configuration of the proposed animal depression

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therapy device in this study. Symbol 1 represents the central functioning microprocessor, symbol 2 controls the LCD display window, symbol 3 is the battery power unit when using the built-in charging feature for DC power, and symbol 4 serves as the AC adapter. Symbol 5 manages power control and management, while symbol 6 handles triac drive, symbol 7 handles IGBT drive, and symbol 8 handles SCR drive functions. Symbol 9 represents Wi-Fi, symbol 10 is the Cell Phone that communicates with the device, symbol 12 is Bluetooth, symbol 13 manages various sensors including EEG units, symbol 14 represents ECG (EKG), symbol 15 is the D/A converter, symbol 16 is the A/D converter, symbol 17 is the high-voltage control signal unit, symbol 18 represents the charging signal, and symbol 19 manages the discharge control signal. Symbol 20 is the address bus, symbol 21 is the data bus, and symbol 22 operates through calling functions stored in the program memory[8]. Symbol 23 represents spare data memory, and symbol 24 manages real-time clocks. Symbols 25 to 39 represent optional features of the brainwave monitor for confirming depressive symptoms in the brain. Symbols 30 to 35 illustrate the internal components of the depression treatment device proposed in this study. Symbol 25 is the added Bluetooth unit in the sensor section, followed by a critical part of the invention: symbol 26 detects Brain wave signals (Left & Right) and measures abnormal signals to control the therapy device's operation. Symbol 27 is crucial to the invention, as it assesses Brain size signals (Left & Right) to determine and control device operation based on significant differences in brain size between the left and right hemispheres. Symbol 40 enhances the precision of signal analysis obtained from symbol 26 to categorize brainwave types, thus maximizing the precision of therapeutic effects. Symbol 28 represents a comparator, symbol 29 is a high-pass filter, symbol 37 is a notch filter operating in specific frequency bands, symbol 38 is a high-pass filter, and symbol 39 indicates electrodes.Symbol 30 is a phase detector, symbol 31 is the voltage supply control unit, symbol 32 is a transformer, symbol 33 is a rectifier, symbol 34 is responsible for charging functions, and finally, symbol 35 represents the coil responsible for operating the therapeutic stimulus pulses and the ultimate load function[9],[10].

**practal analysis and implement**

Symbol 1 supplies AC power, symbol 2 handles AC voltage control, symbol 3 manages voltage rectification, symbol 4 is a snubber circuit for power component protection, symbol 5 represents voltage charging, symbol 6 is a transformer, symbol 7 is a transformer for rectified voltage, symbol 8 functions as a regulator for AC voltage, symbol 9 is a DC 18-volt regulator circuit, and symbol 10 is a DC 5-volt regulator circuit. Symbol 11 is the central microprocessor responsible for control, symbol 12 is the voltage charging drive circuit, symbol 13 is a compensatory circuit for the voltage discharge circuit, and symbol 14 represents compensatory control signals controlled by the microprocessor. Symbol 15 is an IGBT & SCR temperature compensation circuit, symbol 16 handles the temperature measurement function for IGBT & SCR, symbol 17 compensates for CPU temperature, symbol 18 is the CPU temperature measurement circuit, symbol 19 converts incoming transformer voltage to high voltage, symbol 20 discharges high voltage, symbol 21 represents the stimulation therapy coil, and symbol 22 is the pulse forming network circuit that generates the required treatment pulses based on the pathology. The fast Fourier transform (FFT) analysis method is used to separate waveforms into multiple components, and the processing method follows equation (1).

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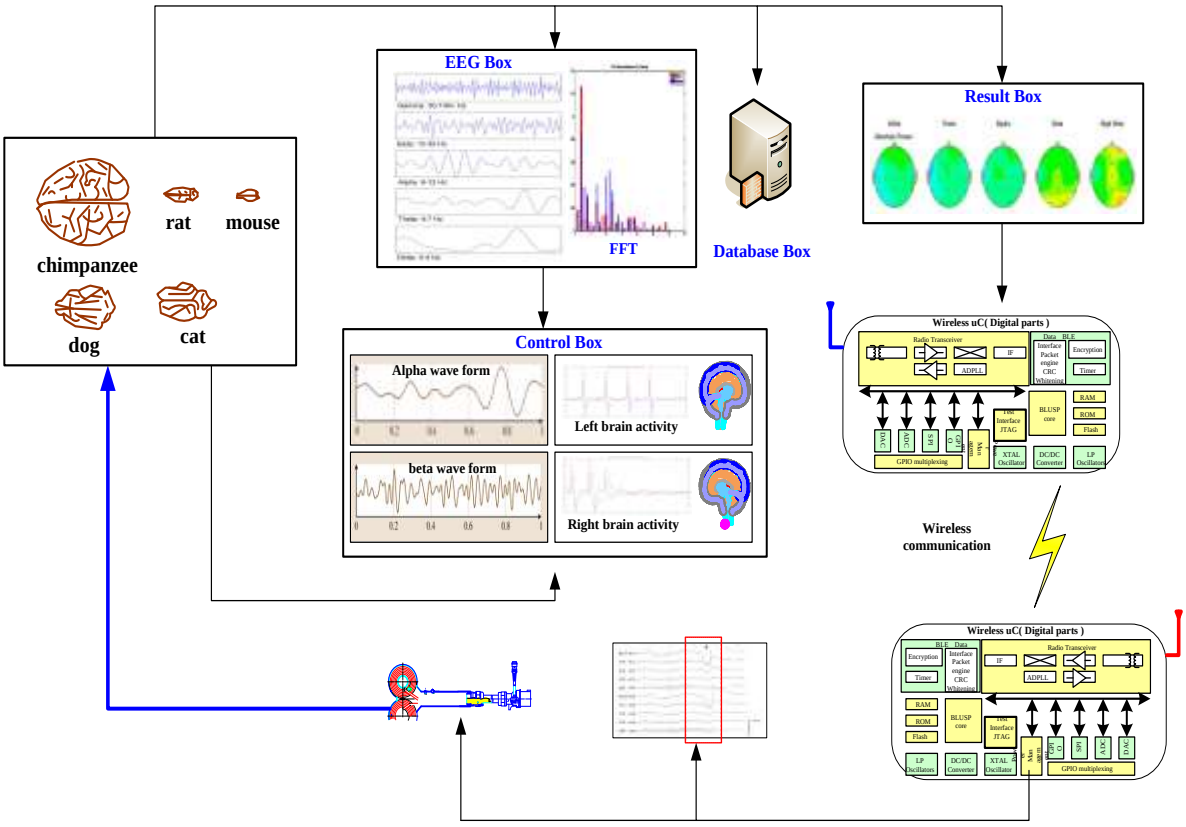


Fig.3 is fundamentally composed of an EEG collector, a control box, and a Results Viewer. In real-time, incoming brainwaves undergo the process of Fast Fourier Transform (FFT).

$$K(f_N) = \sum_{m=0}^{n-1} H_L e^{-J2\pi MN/n} = K_N \quad (1)$$

$$K_L = \frac{1}{n} \sum_{m=0}^{n-1} h_N^{-J2\pi MN/n} \quad (2)$$

The changing time-domain signal is transformed into the frequency domain to assess the signal's characteristics based on frequency variations. The data is classified by frequency components, and the density and distribution of these components are identified. In the cognitive development phase, indicators are applied to ascertain the pattern using equation (3).

$$powerratio f(snr + midb)/\theta \quad (3)$$

Finally, the activity of the left and right hemispheres of the brain is applied to the Alpha Inactivity Mechanism (AIM) based on the theory that brain activity is inversely proportional to alpha waves. The formula is as follows.

$$left = \frac{1}{pactL} \quad (4)$$

$$right = \frac{1}{pactR} \quad (5)$$

Symbols 23 to 27 represent the configuration of the EEG amplifier, symbols 28 to 33 depict the setup for signal analysis, and symbols 36 to 44 illustrate the process of analyzing abnormal states. Symbol 23 stands for the amplifier, symbol 24 is the high-pass filter, symbol 25 represents the notch filter, symbol 26 is the low-pass filter, symbol 27 is the Photo isolator. Symbol 28 is the A/D converter, symbol 29 is Independent Component Analysis (ICA), symbol 30 is Event-Related Desynchronization (ERD), symbol 31 is Linear Discriminant Analysis (LDA), symbol 32 is FFT, and symbol 33 indicates the normal state. Symbol 34 is Spectrogram, symbol 35 isCorrelation, symbol 36 involves EEG signal acquisition and processing, symbol 37 is the digital low-pass filter, symbol 38 indicates normalcy, symbol 39 is Hamming

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function, symbol 40 is Power Spectrum, symbol 41 is 8-13Hz extraction, symbol 42 represents signals in the range 8Hz < signal < 13Hz, symbol 43 implies right signal < left signal, and symbol 44 signifies abnormality. Symbol 45 represents the Bluetooth used to transmit data obtained from EEG signal processing and abnormal measurements. Symbol 46 indicates Bluetooth used for measurement and collection from cell phones or mobile devices, and symbol 47 is a monitoring program visible on cell phones or mobile devices. Symbol 1 represents various brains such as animals and mammals. Symbol 2 represents brainwaves collected from various EEG BOX tools[11]. Symbol 3 represents the Database box. Symbol 4 represents the results of EEG measurements. Symbol 5 classifies brainwaves by frequency. Symbol 6 is the transmitting Bluetooth. Symbol 7 is the receiving Bluetooth attached to the hardware of the animal depression treatment device. Symbol 8 represents Raw data. Symbol 9 is the treatment coil of the animal depression treatment device. Symbol 10 represents samples of the animal's left and right brains. Symbols 11 through 13 represent the composition of the EEG device. Symbol 11 is the high-pass filter. Symbol 12 is the notch filter for detecting specific frequency blockage. Symbol 13 is the amplifier[12]. Symbol 14 represents the application processor. Symbol 15 represents the display screen and control unit. Symbol 16 represents the Bluetooth attached to the microprocessor. Symbol 17 represents the Bluetooth attached to the cell phone. Symbol 18 represents the portable and commercial power supply unit. Symbol 19 represents the cell phone. Symbol 20 represents the EEG data measured from the brainwave measurement device, transmitted to the IoT server platform through the Android IoT app using the oneM2M standard. The collected EEG data is used to generate the SVM (support vector machine) model represented by Symbol 21. Depending on the data, it controls ASMR content. In brainwave measurement, data is transmitted to the Android IoT app (ADNAE) through Bluetooth communication and transformed into standard format[13].

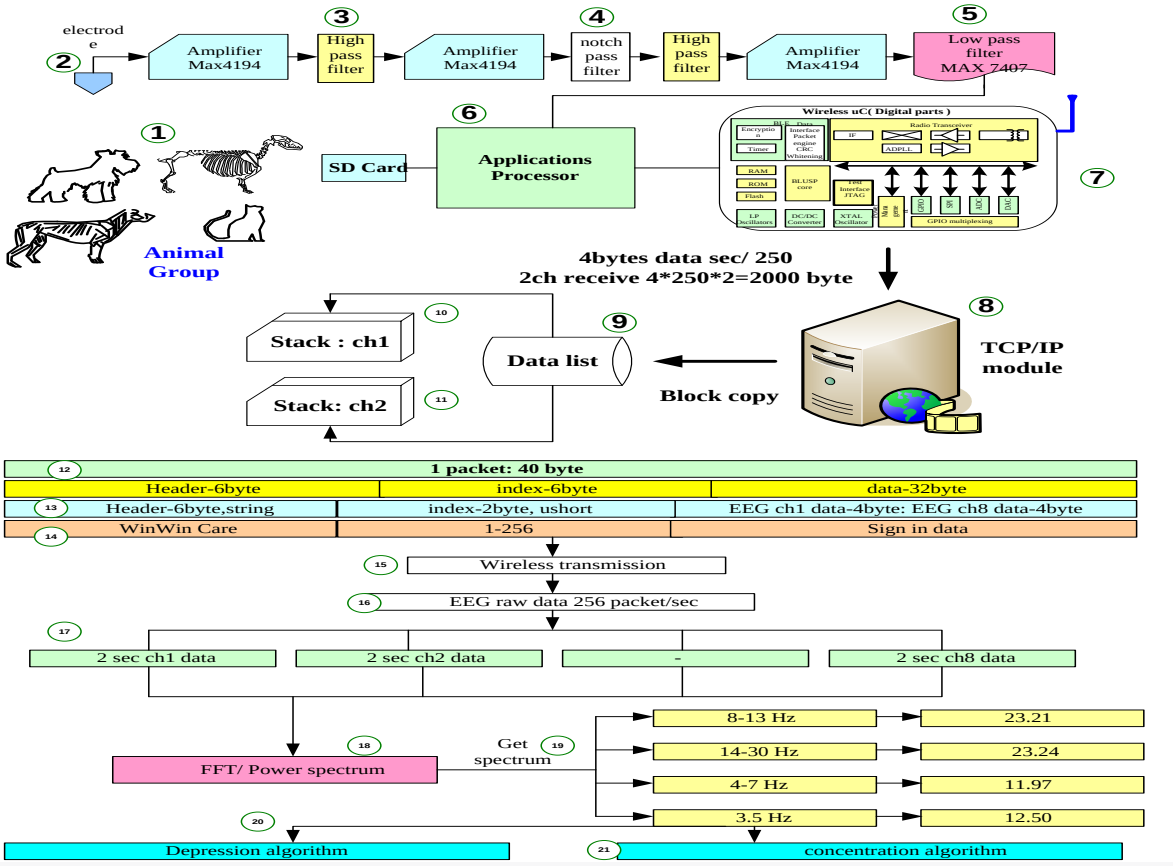


Fig. 4 In the analysis algorithm, depression is analyzed in the frontal lobe 2 channels rather than the frontal lobe 6 channels.

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The TAS (thing adaptation software) acts as an interface between the device and the Android IoT app, transmitting to the Android IoT app based on the oneM2M AE foundation. The oneM2M-compliant IoT server platform registers ADNAE and models as an IN CSE (infrastructure node common service entity) for generating containers and content instance resources. The IoT server platform (INCSE) registers, generates resources, uploads, creates containers and content instance resources, parses instance resources, uploads EEG data, stores it in the MySQL database, and operates the animal depression treatment device when the abnormality and asymmetry are severe. The depression treatment device operates independently based on the stored data in memory and utilizes the continuously updated database on the cell phone to enhance treatment effectiveness. Symbol 1 represents various mammals, while symbol 2 represents electrodes[15]. Symbol 3 denotes a high-pass filter, symbol 4 signifies a notch filter that operates in a specific frequency range, and symbol 5 stands for a low-pass filter. Symbol 6 represents an application processor, symbol 7 denotes Bluetooth, symbol 8 represents TCP/IP, and symbol 9 refers to a data list. Symbol 10 and symbol 11 represent Channel Stack-1 and Channel Stack-2, respectively. In real-time, brainwave measurements are taken to diagnose depression, utilizing the Frontal Brain Asymmetry (FBA) ratio that indicates the asymmetry level of the frontal cortex. The intervals of FBA ratios are validated. Packets including FP1, FP2, F3, F4, and other channels (used for measuring depression) are sent as 4-byte packets at a rate of 256 times per second, as represented by symbol 14. These are stored in a queue for real-time processing within a 2-second window represented by symbol 13. The 2-second window in symbol 13 corresponds to the minimum window size in the Data. To divide brainwaves into precise waveforms, the Fast Fourier Transform (FFT) analysis method is employed. Symbol 13 includes headers, indices, EEG ch1 data ch8 data in 4-byte format. Symbol 15 signifies wireless transmission, symbol 16 represents EEG raw data at 256 packets per second, symbol 17 denotes 2-second ch1 data, symbol 18 stands for FFT/power spectrum, symbol 19 indicates getting the spectrum, symbol 20 relates to the algorithm, and symbol 21 depicts the concentration algorithm.

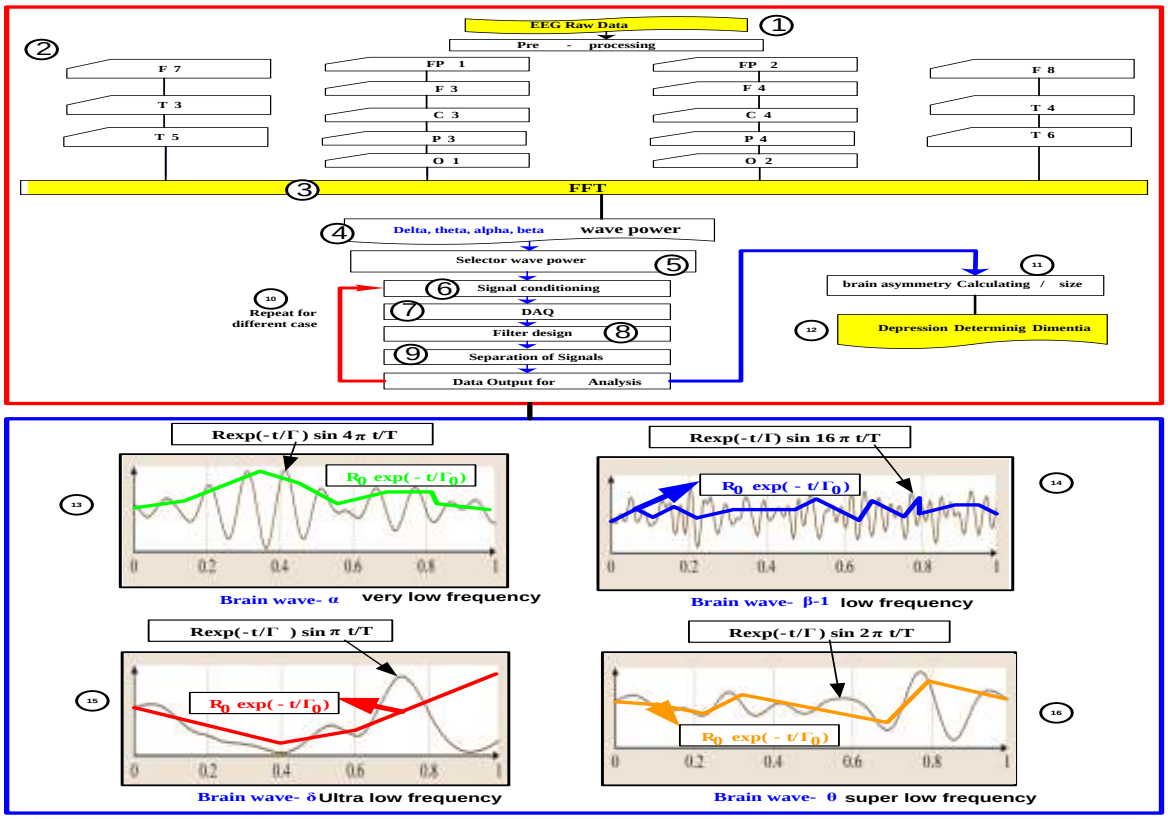


Fig. 5 Data analysis is performed separately for data measured with depression. Brainwave patterns are classified as sine waves and cosine waves with amplitudes and frequencies. Fourier series are utilized.

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## III. EXPERIMENT RESULTS

In the analysis algorithm, there is a clear indication that depression can be more accurately analyzed in the frontal lobe 2 channels than in the frontal lobe 6 channels. After measuring and processing the frontal lobe, if the alpha asymmetry value of the brain data through FFT exceeds a certain threshold value, it can be determined as a state of depression. Symbol 1 represents the acquisition of brain data, symbol 2 represents the 16 channels organized by channel, where the brain's raw data undergoes independent component analysis to remove noise. Once the processing is complete, the brain's data is saved in channel-specific stacks with frequency values. Symbol 3 indicates the application of FFT to the data in the channel-specific stacks. The frequency values obtained through the FFT module using symbol 4 can determine the frequencies of specific bands such as alpha, delta, and gamma over time. Symbol 5 represents the wave power selector, symbol 6 represents the signal conditions, symbol 7 represents data acquisition, symbol 8 represents filtering, and symbol 9 represents brainwave classification. If there is a significant difference in the output data due to analysis in the next step, the system will loop back to step 6 for further feedback. Symbol 11 provides insight into brainwave symmetry and size. Furthermore, the alpha asymmetry values are applied to the FBA algorithm, producing a ±0 to ±1 brain asymmetry level, where values close to 0 indicate symmetric activation of the left and right brain, values close to +1 indicate asymmetric activation of the left brain, and values close to -1 indicate asymmetric activation of the right brain. Symbol 12 allows for indirect discrimination and prediction based on the overall brainwave pattern. For the initial conversion of signals to neurodynamic signals after the first-stage processing, the dynamics of initial information are utilized through mechanical codification. The modulation method is signal codification, where the key lies in the parameters' binary code combination composed of continuous pulses to transition the initial function. Symbol 13 represents very low frequency, symbol 14 represents low frequency, symbol 15 represents ultra-low frequency, and symbol 16 represents super low frequency states, indicating Brain wave-δ, Brain wave-θ, Brain wave-α, and Brain wave-β.

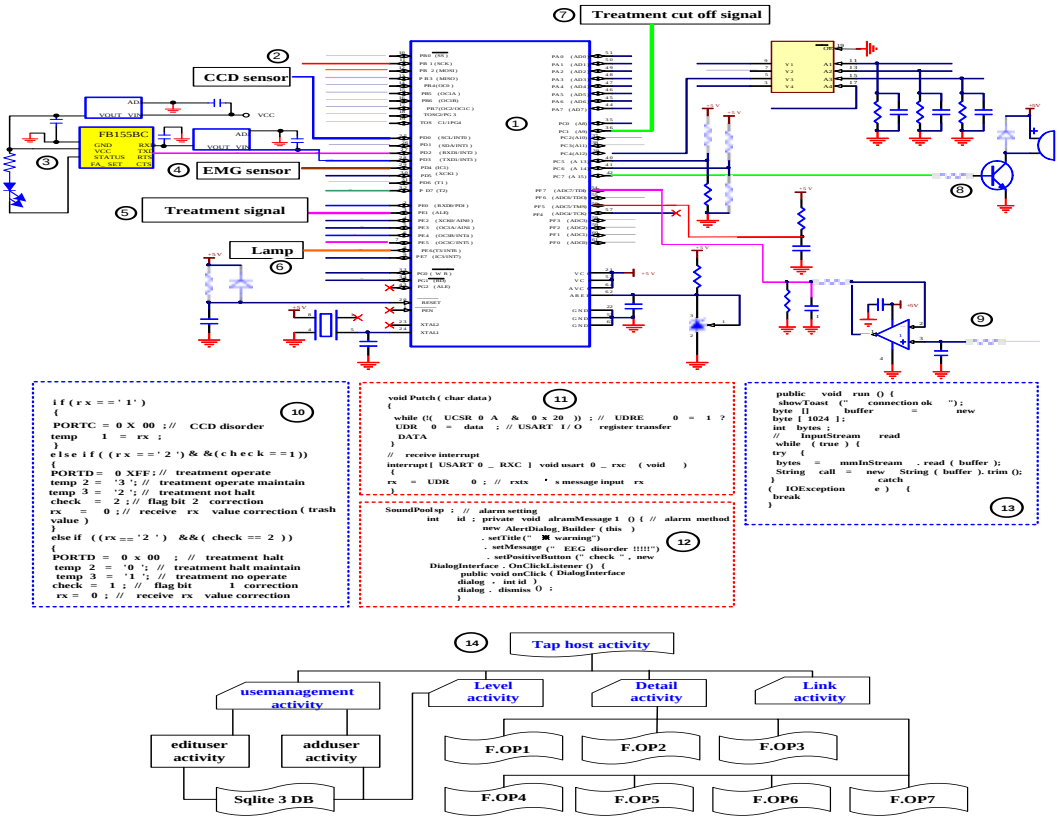

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Figure 6 illustrates a system that operates independent of location and time, offering diverse monitoring capabilities across various areas. It provides location settings and accesses symbol 3's server through wireless communication networks. When moving out of a specific region, data is stored in the database.

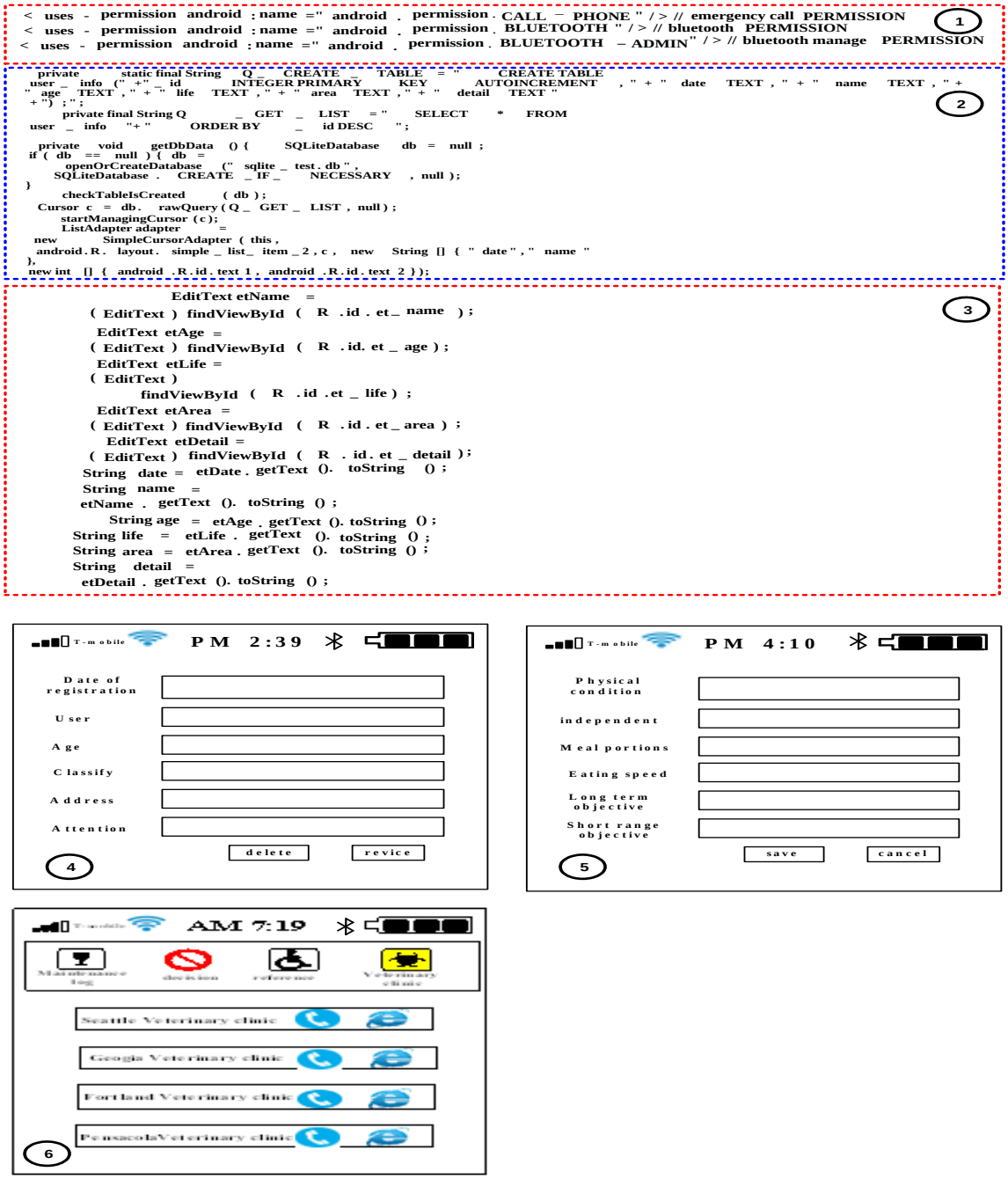


Fig.7 involves creating a database using the OnCreate method of symbol

Figures 6, 7, and 8 depict the functions related to treatment, communication, control, and contact through cell phones. Primarily, utilizing CCD-CMOS sensors, skin sensors, and Bluetooth communication technology, the proposed approach aims to manage urgent situations like shingles and pain treatment. It enables rapid treatment capabilities via cell phones. The method applied to

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animal patients (symbol 1) reduces economic, physical, and psychological burdens. Accumulated database information sent to symbol 2 facilitates patient consultation and treatment. It supports treatment coordination with facilities and specialized services. The proposed device establishes a system that is not limited by location or time. Utilizing CCD-CMOS sensors and skin sensors (symbol 3), the system accesses the server via wireless communication networks. When leaving a certain area, the system sends lesion information and location data to cell phones of registered caregivers (symbol 4). CCD-CMOS sensors and skin sensors (symbol 7) detect Bluetooth and switch to appropriate activities during emergency situations. GPS and voice recognition can be added to cell phones to enhance monitoring in potential situations.The GUI-based (symbol 8) disease tracking and diagnosis system facilitates emergency treatment. It establishes a data system to manage patient information, upload, feedback, disease research, and patient management. The proposed device allows doctors, experts, and caregivers to participate collaboratively through the collection and transmission of biometric information via cell phones and sensors. The application includes uploading, feedback response, disease research, and patient management systems. The operational environment involves CCD-CMOS sensors, skin sensors, and a microprocessor (symbol 2). It utilizes a microprocessor like MSP430 or AVR series, with ATmega 128 used in this case. The system employs open-source broadcast and URL to link with external institutions' websites and establish connections. The system utilizes cell phones and sensors to collect biometric data and send it wirelessly to medical facilities. The device can trigger alerts, upload data, and initiate feedback responses. The communication between sensors and cell phones involves Bluetooth. Received messages are processed, and sensor module outputs are controlled through USART I/O registers. The device connects to ATmega128 with 5V and 30-50mA, utilizing pins 7 and 8 for transmission and reception. The system sends and receives 1-byte signals through USART I/O registers, utilizing interrupts and ADC readings for sensor data conversion. In case of abnormal detection, the device activates an alarm code and sends emergency codes to cell phones. The application facilitates emergency alerts (symbol 12). The application and sensors work together to operate the animal shingles and pain treatment device (symbol 5, 7) and stop it after treatment.

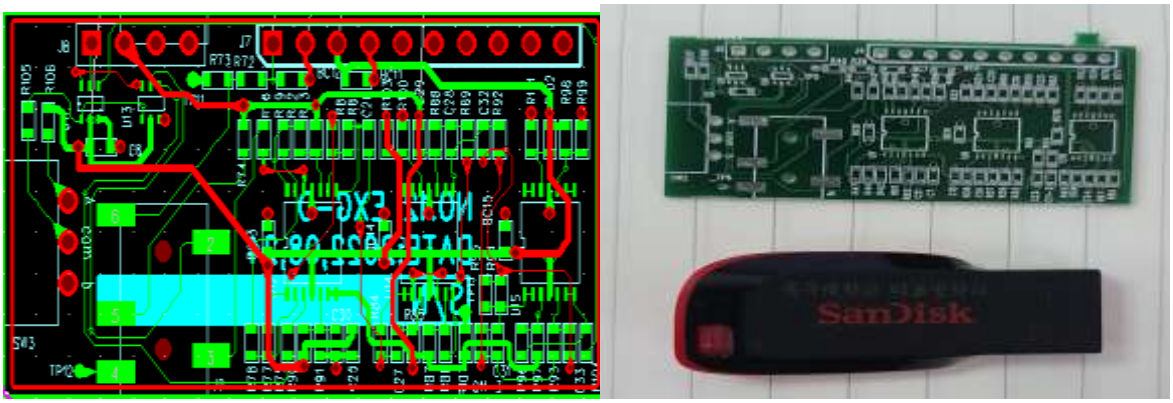


Figure 8 shows a prototype implemented with electronic medicine.

## IV. DISCUSSIONS

Create login and registration buttons, and create EditText fields for ID, password, age, address, residence type, daily life, ecological information, and more. Then, utilize the SetOn Click listener method..The creation of the database involves using the OnCreate method of symbol 1. Create login and registration buttons, and create EditText fields for ID, password, age, address, residence type, daily life, ecological information, and more. Use the SetOnClicklistener method to check for the duplication of IID and password information. Symbol 2 represents the code for creating the DB base and structuring the table. A table named User_info is created to automatically increment user IDs and add Text-type keys. Retrieve the table values and keys from Sqlite_test using symbol 2. Symbol 3 represents the code for taking user input and inputting data into the generated table for updates. Collect a list of Key values from EditText input and save them as String values to the DB file. The implementation result of the mobile

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application is represented by symbol 4. For early diagnosis and treatment, lifestyle and health management information is collected from related parties and guardians, which can be referenced in external evaluation indicators such as cognition, neurology, BPSD, daily living activities, and functional abilities. External guidelines can also provide support, and the progression of lesions can be continuously monitored. In case of emergency situations, safe measures can be taken. Furthermore, it supports data collection and diagnostic assistance. The implemented screen allows users to input their name, residence type, age, residence area, and save the information. Then, the external medical institution's treatment record screen is displayed. Data collected on a weekly or monthly basis is used for diagnostic and treatment management. This approach can verify the diagnosis of shingles and post-shingles pain treatment.

The screen implemented in symbol 5 allows regular input and observation of symptoms and functional abilities that occur in daily life. Activities, mentality, eating, excretion, bathing, clothing, and cleanliness status can be evaluated based on the results observed by family members or guardians and rated on a scale of 1 to 5. Observations and inputs related to eating activities, meal quantity, speed, independence, etc. are completed, and upon completion, the downloaded external indicators are used for diagnostic evaluation. Diagnosis evaluation is then referenced for level judgment. Alternative intervention treatments such as treatment, medication, correction support, and facility program support are provided through short and long-term goals. Symbol 6 represents the screen for integrated treatment support. Based on management support and level judgment results from observation, if outpatient treatment is difficult, patient information can be linked to nearby animal hospitals or specialized medical institutions to facilitate effective treatment. Appropriate intervention and integrated treatment based on behavioral and psychological symptoms (BPSD) and physician diagnosis are suggested. Symbol 7 involves communication between cell phones and devices to set up and perform early treatment based on diagnosis and situations."

## V. CONCLUSION

The new antidepressant treatment method utilizes localized magnetic field waves induced on the surface of the skull through self-stimulation, stimulating the cerebral cortex. This non-invasive procedure holds significant potential for therapeutic applications due to its ability to stimulate the local brain region. The effectiveness of treating depression is closely related to the functioning of the prefrontal cortex. Various studies on stimulation of the prefrontal cortex have shown that stimulating the dorsolateral prefrontal cortex can induce brain activity and achieve antidepressant effects. Furthermore, the portable magnetic stimulation therapy device according to this invention can be adjusted to perform functions such as coil detachment and replacement using the Superposition method. This device not only provides simple neural stimulation but also converts the current pulses of magnetic stimulation into neural energy when applied to the biological nerves. This energy is then used to stimulate neural activity, promoting conditions like depression or brain-related therapies and pain relief. By utilizing these neural stimuli, the device aims to prevent brain nerve damage, making it highly versatile and effective for various purposes.

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