Practical Design of Intelligent Reminder System of Having Medicine for Chronic Patients

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Abstract: - This research is originally creative research, and already applied patent under authority of Patent Bureau of Taiwan (Authorized Invention number: I No.287982). People living in modern society are full of much pressure from all kinds of environment everyday and with the great change of dining habit people easily have many chronic diseases. In addition to causing huge damage to individual health, it also cost much society medical resource. Most chronic diseases need special care from nursing staff to remind of when to have the correct medicine. It is naturally proceeding in wards but patients usually forget to punctually have medicine once they leave the hospital and get back home, and this situation neglecting or forgetting to have medicine according to doctors' instruction often causes many un-fortunate deaths of patients resulting in offsetting-less for individual and family. The research category of this study are including a medicine box as the main part of product which includes GSM module, speech-functional DSP, control panel displaying all information for patients, medicine detecting function, and a single chip microprocessor to operate the monitoring function. On the other hand, the interface of the commander terminal PC in nursing center, instructing all information for patients to punctually have medicine, is developed by us programming with VB language. The system function was verified completed successful and could be published for commercials for its creativity and practical purpose.

Keywords GSM communication module, speech-functional DSP, Intelligent monitoring, Microprocessor, Interface

1. Study Motivation

People living in modern society are full of much pressure from all kinds of environment everyday and with the great change of dining habit people easily have many chronic diseases. In addition to causing huge damage to individual health, it also cost much society medical resource. Most chronic diseases need special care from nursing staff to remind of when to have the correct medicine. Owing to the speedy development of communication technology and semiconductor, GSM communication module can be integrated and embedded into single chip and let GSM be carried into many products to increase the added-value of products. So how to combine microprocessor with communication module to construct a safe, intelligent, and full-purpose monitoring system for individual to have medicine to solve the problem mentioned above becomes an interesting issue for us.

2. Study purpose

Base on the study motivation mentioned above, The research category of this study are including a medicine box as the main part of product, including GSM module, speech-functional DSP, control panel displaying all information for patients, medicine detecting function, and a single chip microprocessor to operate the monitoring function. On the other hand, the interface of the commander terminal PC in nursing center, instructing all information for patients to punctually have medicine, is developed by us programming with VB language. The monitoring system has dynamic monitoring screens, auto-oral -notifying system, alarm system, timing & procedure management for having medicine, and auto-tracing patients system by GSM system to deal with all kinds of patients without punctually having medicine.

The whole system has superiorities such as bi-direction communication-interface being able to real-time manage all emergency, and notify close friends or family of the patients whether they having medicine according to planed schedule punctually or not so as to further protect their health.

3. Importance of the Research

It is wonderful to concrete the conception "implementing knowledge into real life" and try to lead automation conception into daily life; furthermore, let people feel the convenience and practical function of technology.

This system make it significant that the mission of simple but not being neglected for having medicine of patients is taken over by hospital through auto-detecting and monitoring on servo computer in nursing center and can insure patients' having medicine according doctor's prescription punctually as well as their health. This invention also provided

records of chronic patients to make patients having medicine simple, informational, and systemic. Furthermore, in this system, combining computer communication function, GSM wireless system, and serial communication technique of microprocessor to becoming local communication system not only obtain a complete communication system but also enrich the extra-value of unique system.

4. System Structure and Operating Directions

4.1 System Structure

The whole system-structure of the medicine box for certain individual patient, in which an intelligent monitoring system was designed and whole circuits was PCB-layout in the box, was shown in Fig 1. The system included GSM communication module that received patient's information of whether having medicine or not and transmitted the information to the nursing center in hospital as well as received the response information from center for being indicated on medicine box to correctly decode the echo code as to control alarm-system, oral-message and LCD displayer to remind patient to have medicine punctually.
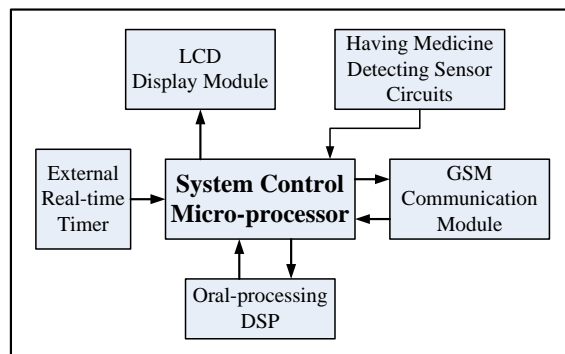

Fig 1 Patient's medicine-box system structure

System control microprocessor in patient's medicine-box was responsible for scanning the condition of sensors that detected the status whether the medicine was had by patient on time or not and coded those statuses before transmitting the information to GSM module which would send back to nursing center in hospital in time to proceed proper response. Meantime the alarm-led on every unit (medicine block which medicine put there in advance) and built on medicine-box would flash to notify the patient or their family to have the medicine. The LCD module would display the information including whether punctually having medicine, the message receiving from main console in nursing center in hospital far away, the patient's coding No., present time, the name of the medicine, and what meal of medicine the patient should have. Chinese characters coding database was used to transfer information into

Chinese to display on LCD displayer. External real-time IC provided the real time base for system as reference time on slave device---medicine-box.
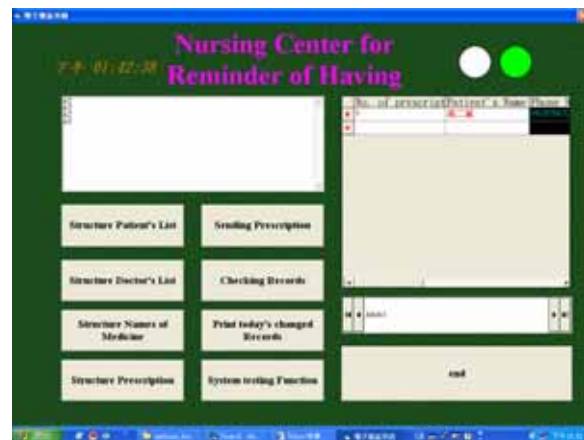
4.2 Operating Directions

Fig 2 Executed monitoring screen of nursing center
---Initialization Screen

The operating of having medicine reminding system could be divided into two parts---PC-based Main Console computer with Graphic Interface System (GIS) designed by ourselves with Visual Basic Language. The initialized screen was shown in Fig 2. The main executing functions were as follow:

Structure Patient's List: it could be keyed in patient's name by doctor or nurse who was attending the patient in hospital and structured the whole name database of patients.

Structure Doctor's List: When the doctor attend the patient, he (or she) would key in his own name and system would record the time curing patient, location, attending nurse all the information into database for further responsibility in case of curing conflict occurred.

Structure Names of Medicine: After finishing patients' attending, the doctor could give prescription for the patients and recorded into system database and download the prescription to medicine box in patient's home through GSM net in order that the patient's having medicine situation could be detected according the prescription (It contains the information of what kind of medicine, when to have, how many meals the patient should have medicine etc.)

Send Prescription: After pushing the function button, the prescription would be sent to the medicine box in patient's home through GSM net.

Check Records: In hospital, nurses or doctors could check the records of having medicine of some specified patient by keying in patient's name, and then push this function button. The outcome of checking records of patients was shown in Fig 3. In Fig 3, if the red block appears on the table, it means the patient didn't have the medicine according to the prescription schedule, and the time has exceeded more than one

hour. If the block appearing on the table is yellow, it means patient had the medicine after reminding, and white block means having medicine punctually.

Fig 3 Executed monitoring screen of nursing center --- Screen of response information of having medicine situation on medicine-box

The operating directions of Slave device---medicine box was described as following:

The system microprocessor would scan the having medicine situation of patient, if the patient didn't have the medicine according to doctor's prescription on time over one hour, the LED on box would flash to remind patient or his family to have the medicine, on the other hand, the oral-DSP would give out oral message to remind patient as well as the related message would be shown on LCD displayer. In the front one hour, the patient had the medicine, then the responded screen on Main console PC in hospital would be yellow block as Fig 3. If patient didn't have medicine during this meal to the next one, then the block would appear red color, and if patient had had medicine in time, the block would be white color.

If patient didn't have medicine more than one hour, the system of box would send out SMS message through communication system to warn patient and remind them to have the medicine.

5. Hardware of Project Design

The whole system of Intelligent Reminder System of Having Medicine for Chronic Patients could be designed with five sub-systems as following:

(1) System circuits of scanning status of having medicine.
(2) Full-multiplexer local communication system between GSM module in medicine-box and main console in nursing center in hospital far away.
(3) Point-matrix TFT-LCD displayer system.
(4) Sensors to detect status of having medicine
(5) Oral-processing DSP system.

The description of all sub-system explained as following.

5.1 System Communication Structure

Main control console (It could be located in hospital nursing center or in PC of patients' houses) which could access time of having medicine according to every meal and sleep time of patients through designed graphic interface with Visual Basic language. Every time when patient ought to have medicine, the main console would transmit SMS message to GSM module through Com port   The Slave device called medicine box would receive the message and the microprocessor in medicine box would decode control code from main console and correctly response what action should be taken.
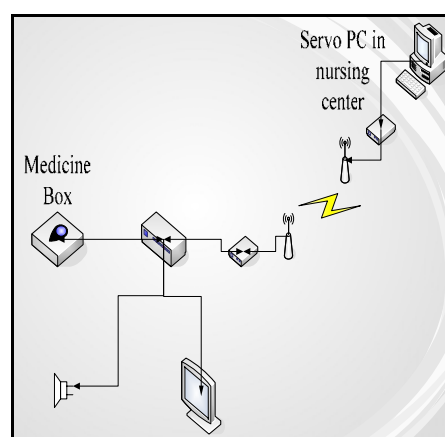

Fig 4 Conception of system communication structure

The main tasks of Slave device (medicine-box of patient) are

(1) Receiving SMS message transmitting through GSM from servo PC (main console) in nursing center in hospital far away including schedule of having medicine, password, patient's name, time for having medicine, name of medicine.
(2) Scanning the real statuses of having medicine indicated on the medicine-box. When receiving command message from system processor on medicine-box, the detected circuit would scan every medicine collecting unit whether the medicine was had by patient punctually or not through sensors circuits, and then response the status code to servo PC in nursing center to take proper action.
(3) Alarm device, which would send out related information onto LCD displayer as well as oral message and flash led to warn the patient not having medicine in time and even automatically call out to the patient if he or she was outdoors. But if the medicine was had in time then the message would be ignored.

5.2 Hardware design of medicine-box

Fig 5 was the indicated LEDS on the medicine box, the function of which were displayed which meal medicine not being had by patient. There were 28

divided boxes for 28 meals in a week to contain the medicine, which were detected whether the medicine were had according to the schedule through sensor circuits, but the sensors signals were too many to meet the input pins of microprocessor, therefore, we designed special circuit in which sensors parallel signals were converted to serial signals with IC HEF4094 (Fig 6). Since HEF4094 has no latch function, we used IC ULN2003A (Fig 7) as buffer to latch the data shown which meal medicine without having according to schedule.

Fig 5 indicated LEDS circuit on medicine-box
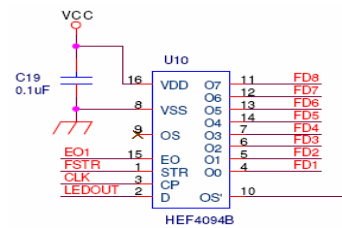
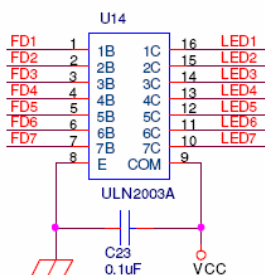Fig 6 Parallel data convert into serial data interface

Fig 7 Data latch buffer

The output voltage of LM339 (Fig 8) would shift two values 0 Volt and 5 Volt depending on whether the medicine were taken away or not, that meant if the medicine was had by patient, then the LED would light on CDS and the output of LM339 was 0v, on the contrary, if the medicine hadn't had and still laid between LED and CDS, the output was 5v. We could collect all detected signals by IO port of microprocessor to judge the situation of having medicine of patient for each meal. Since general microprocessors only have less IO pins, our sensor circuit for medicine were designed 28 input signals to correspond to a week amount of medicine; therefore, we selected IC 74HC166 (Fig 9) to receive the detected signals of situation of having medicine. The purpose of IC 74HC166 was to convert the parallel data to serial data so as to both save more IO pins and enough to be able to detect the sensor signals.

IC 74HC166 sent out every bit of sensed signal

according to front edge of CLK, and then grounded CKE, afterwards, took advantage of PE to execute reading processing, finally, used RESET to start sending serial data. If we connected the pin of QH of previous IC with pin SDI of next IC, we could send many set of data simultaneously by properly control RESET.

Because LM339 is one high speed comparator and its output is open-collected, it needs one pull-up high resistance. In the circuit of the function of sensors CDS, which would sense the change of light resulting from whether the medicine was taken away by patients and indicate the change by voltage change of LM339 outputs.
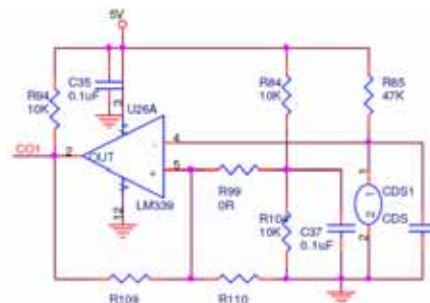

Fig 8 Medicine sensor circuits with LM339 comparator and CDS resistances
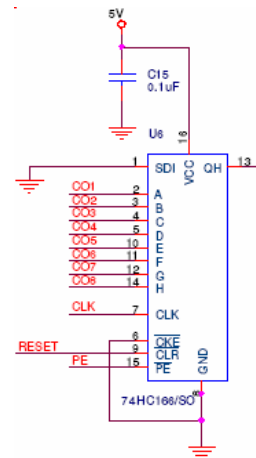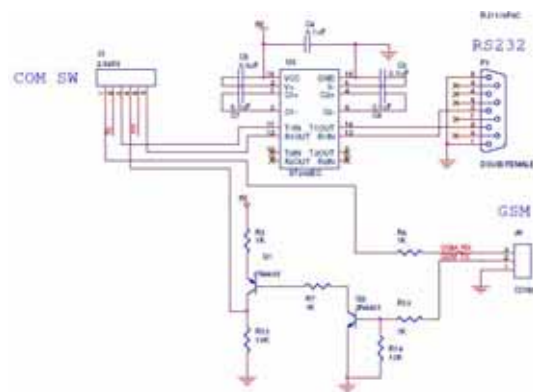

Fig 9 Parallel data convert to serial data

Fig 10 Interface design between GSM and microprocessor and level-shifting

Fig 10 is the RS-232 transmitting interface between microprocessor and GSM module. Because the output voltage of our GSM module is 3V, but RS-232 connected to microprocessor needed 5V; therefore, we designed a level shifting circuit with one NPN and one PNP transistor as shown in Fig 10.

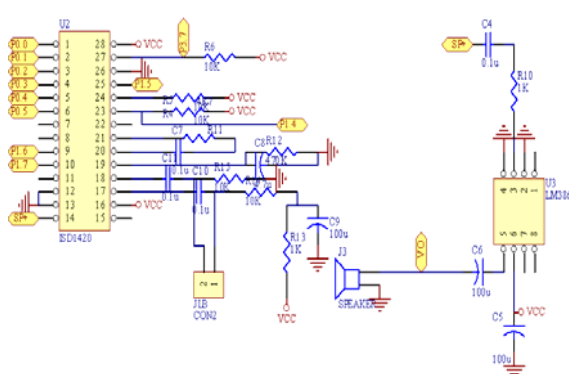## 5.3 Voice Interface Design on Medicine-box

Fig 11 Reminding Voice Circuits Design of Medicine-box

Address bus of ISD1420 have two functions; one is to decide the input function of A0~A7 by the voltage level of A6 and A7. If one pin of A6 and A7 is low, then A0～A7 will all input low and this means A0～A7 would be the initial address of recorded voice data. Meanwhile, the address bus only act like input pins function and can't output the internal address information during the operation period. The input signals of address are latched according to the falling edge of signal PLAYE, PLAYL, or REC. It's forbidden that A6 and A7 cannot be the high level at the same time, the sub-system was shown in Fig 11.

The front four bits of the 8bits of address bus decide the length of recorded voice , for example if the start address of first section of recorded voice is 0000000, it means the voice length will be 0 seconds per section, it has been defined by the IC manufacturer. if the start address of second section of recorded voice is 00010000, it means the voice length will be 2 seconds per section, and 00100000 defined the voice length will be 5 seconds per section….etc. This means we can easily to decide how long we hope the recorded voice every section and its starting address.

The follow is part of recorded voice programming by assemble language of single chip microprocessor 8051, The whole recording time is 20 seconds (it depends what kind IC you selected), we divided it into 10 sections, so every section was distributed 2 recorded time. The part of related program was programmed as following:

```
ADD_V1:
MOV      P0, #00000001B
CALL A6_LO
CALL      A7_LO
RET
;----------------------
```

```
ADD_V2:
MOV      P0,   #00010000B;   OFFSET   2   SEC
ADDRESS=16
CALL      A6_LO
CALL      A7_LO
RET
;----------------------------------------------------------------
ADD_V3:
MOV  P0, #00100000B; OFFSET 4 SEC ADDRESS=32
CALL A6_LO
CALL A7_LO
RET
;----------------------------------------------------------------
ADD_V4:
MOV  P0, #00110000B; OFFSET 6 SEC ADDRESS=48
CALL A6_LO
CALL      A7_LO
RET
;----------------------------------------------------------------
ADD_V5:
MOV  P0, #01000000B; OFFSET 8 SEC ADDRESS=64
CALL A6_HI
CALL      A7_LO
RET
;----------------------------------------------------------------
ADD_V6:
MOV  P0, #01010000B; OFFSET 10 SEC ADDRESS=80
CALL A6_HI
CALL      A7_LO
RET
;----------------------------------------------------------------
ADD_V7:
MOV  P0, #01100000B; OFFSET 12 SEC ADDRESS=96
CALL A6_HI
CALL      A7_LO
RET
;----------------------------------------------------------------
ADD_V8:
MOV  P0,   #01110000B;   OFFSET   14   SEC
ADDRESS=112
CALL A6_HI
CALL      A7_LO
RET
```

6. Software and Communication interface design of medicine-box

In this project, we used GSM cell-phone to develop the system communication platform that was main based on the mechanism with cell-phone to send all information and short message to remind patient to have medicine in time and attached some controlled codes at the end of SMS message in order to provide correct having medicine through internet.

6.1 Protocols of communication

(A) Nursing center to medicine box

Table 1 Communication protocol of nursing center

Command bit (3)	Patient's number (8)	Medicine sheet No. (8)	Time (6)	The first having (2)	No. of tablets (28)

Command bit   CTB --> center to box
Patient No.
Medicine Sheet No.
Time   Year   Month   Date
First Having Time   The first Checked Having Time
Coding Number   Coding No. of Having Medicine according to the location in Table 2.

Table 2 Coding No. of having medicine

Time	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Morning	1	5	9	13	17	21	25
Noon	2	6	10	14	18	22	26
Evening	3	7	11	15	19	23	27
Night	4	8	12	16	20	24	28

(B) Medicine-box To Hospital Nursing Center

Table 3 Communication Protocols of Medicine-box

Command bit (3)	No. of Medicine Sheet (8)	Time of Having Medicine (2)	Status of Having Medicine (1)

Command Bit   BTC --> Medicine-box to Nursing center
No. of Medicine Sheet
Time of Having Medicine   Echo Status of Time of Having Medicine
Status of Having Medicine
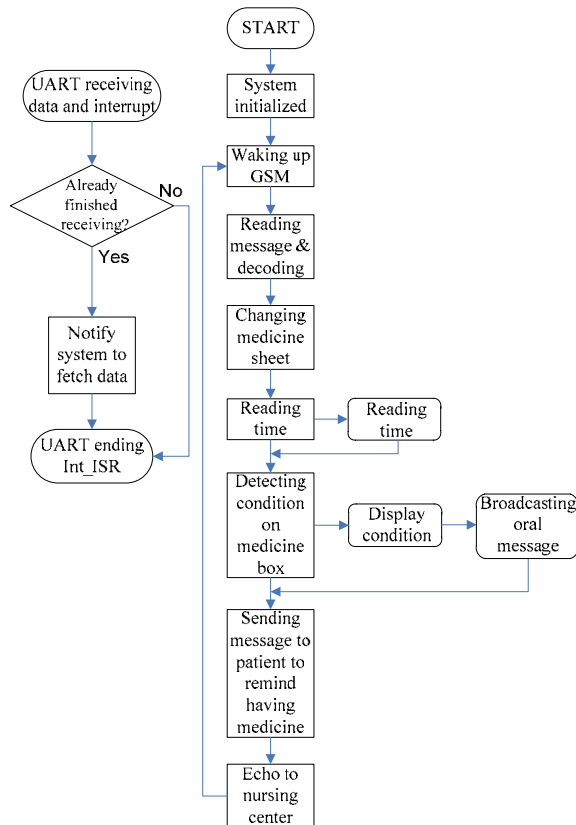　　　　　　　　Not Having Medicine
　　　　　　　　Delaying Having Medicine

Fig 12 Control flow-chart of medicine-box

6.2 The software flowchart of operating procedures in nursing center with VB

This is the software flow-chart of monitoring screen in nursing center in hospital and its scanning screen as shown in Fig 3, and the main scanning screen is the entrance point for entering all sub-functions and indicating the echo information of having medicine of patient from medicine-box. This screen would

wake up the GSM module every 3 seconds and check whether there was any echo message of having medicine from patient's medicine-box. If there were messages came in, the system would first judge whether the message content was strings led by CTB. And if it were, then next step was fetching medicine prescription NO., meal coding of having medicine, and all information related having medicine of patient from short message. After fetching, and then writing data into database. Finally, the system deleted the message and back to initial condition. Related programming in Fig 13.
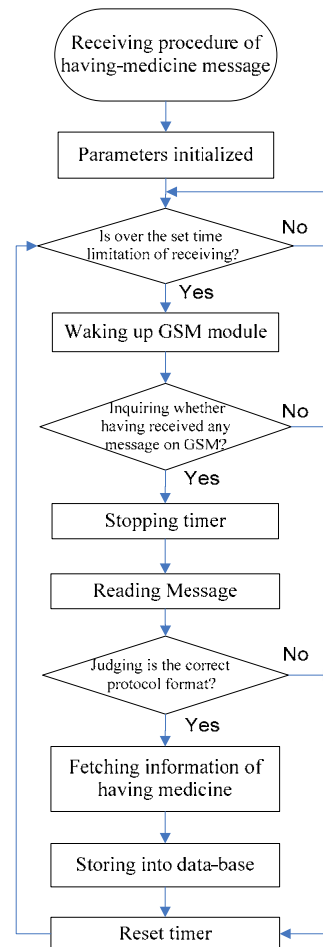

Fig 13 Control software flow-chart of monitoring screen in nursing center in hospital (1)

This was the flow-chart of the function which the doctor made the prescription for patients in Fig 14, and the procedure must begin with inputting the coding No. of patient's and doctor's to make sure that the medicine sheet was really made by doctor. The next we must input total days having medicine, first, input the name of medicine and then what day and what time (meal) the medicine should be had by patient. All pills must be input step by step. Finally, the system would save such information about the medicine after checking whether there was any missing data of every related input item. After all data was saved in the database, we could print the medicine

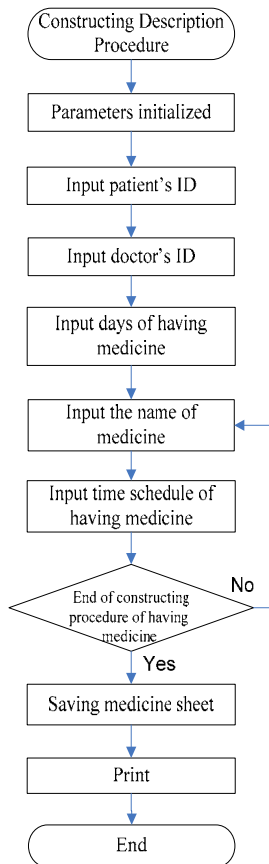sheet or prescription out as reference for patients to have correct medicine in time.

Fig 14 Control software flow-chart of monitoring screen in nursing center in hospital (2)

The medicine sheet (prescription) would be sent to medicine-box through GSM communication module. But before sending, we must input the coding No. of medicine sheet and check whether there was the medicine prescription in the database. If there really were, then the system would show out the coding No. of the patient and the content of the medicine to let the doctor to check. When there was no any error, the system would link all the information about patient's having medicine and coding by program so as to transmit the message to medicine-box in patient's house through GSM module. The software flow-chart of this procedure was shown in Fig 15. The operating screen was shown in Fig 2.

In order to make sure patients' having medicine according to doctor's prescription, especially for those chronic ones, in this monitoring system a function designed for doctors' checking the patient's status of having medicine was that first doctor need to input the coding No. of the patient, and then the system would list out all prescription of the patient. The doctor could select one of them and the system would show out the status of having medicine, which was offered with graph after data transferring. The shown screen was in Fig 3. and the software flow-chart was shown in Fig 16.
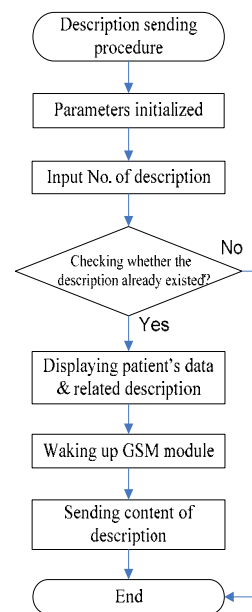

Fig 15 Control software flow-chart of monitoring screen in nursing center in hospital (3)
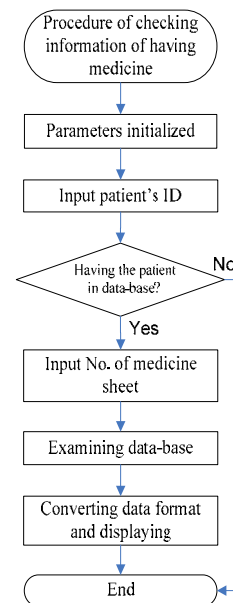

Fig 16 Control software flow-chart of monitoring screen in nursing center in hospital (4)

7. Conclusion

This research tried to combine local communication system with automation conception to implement into an intelligent system which was strongly prompted by the Taiwan National Science Council as well as important development for high level education system by Taiwan Education Minister so as to create the next competition power of Taiwan's industry. In this study project we adapted an intelligent system applied in our daily life space and combined local web-net, voice-DSP, TFT-LCD displayer control, GSM communication, and special sensors techniques to produce a medicine-box and its related monitoring

mechanism suitable for both in patient's house and hospital. The originally creativity was appreciated by many manufactories and the final products has achieved the patent.

Acknowledgements

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