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A Novel Consumer Clock Device Based on Grey Relational Analysis

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***Abstract*—People have the need to use a novel consumer clock device for home automation, personal security and convenience. This paper presents the design and implementation of the innovative system. The system architecture which is controlled by Micro-Controller Unit (MCU) includes main alarm clock module, lucky module and security module. In the main alarm clock module, we create a novel hourglass clock model and intelligent alarm clock features based on grey relational analysis. In the lucky module, we design a unique structure of live round according to the medical theory of psychology and hashing function for randomization. In the live round, it includes the fortune of love, career, family, and health. It adopts funny and encouraged voice to transmit messages. The system also provides the function of security using infrared sensors and third-generation (3G) mobile phone unit. The system has been successful and gets the award in Taiwan.**

***Index Terms*—Micro-Controller Unit (MCU), live round, grey relational analysis, hourglass.**

I. INTRODUCTION

The rapid development in consumer electronics technology has made the use of convenient and practical appliances expand exponentially. Although many information appliances has been currently developed for the home and personal requirement. They can also be used in home automation which provides 1) increased comfort, 2) greater safety and security, and 3) efficient use of energy. But people also have the strong need to use unique and novel devices in the modern society, and people relax themselves and don't have to worry about anything in the bedroom.

A. Alheraish [2] had proposed a home automation system which is based on the wireless GSM network. This is a more expensive way to control home appliances compared to the approach which use the Internet [1]. Kanma *et al* [3] also presented a home appliance control system architecture over Bluetooth technology. The approach in [3] also uses a cellular phone with Bluetooth communication capability to locally control home appliances. The cellular phone can also report statuses to or download manuals and programs from the remote service site via the internet. The initial cost is high because of the cellular phone with both internet and Bluetooth services, and those Bluetooth communication modules for home appliances. Although, Al-Ali and AL-Rousan [1] devised a less expensive Java-based home automation system, a dedicated home server to run Java server pages and Java beans is necessary. Moreover, the Java-based home automation system controls only the on/off states of home appliances. Actually, home appliances may be controlled according to several environment states, low-cost, portable, novel and unique. These situations are not considered in previous results [1-3]. For example, a timer control device can help user to turn on or off a home appliance after a specific interval of time. It is also low-cost, portable, novel and unique for home, outdoors, office and travel. Therefore, a novel low-cost clock device with main alarm clock module, lucky module and security module is devised in this paper. The device can also be combined to implement complex functions by extendable modules for home automation. The unique system architecture adopts modular design and is controlled by programmable Micro-Controller Unit (MCU) using HT46R24. In the main alarm clock module, we create a novel hourglass clock model for time display, sound recording memorandum unit and intelligent alarm clock features to wake up user effectively based on grey relational analysis. In the lucky module, we design a unique structure of live round according to the medical theory of psychology and hashing function for randomization. In the live round, it has aromatic unit for comfort and can determine the fortune of four fields, including love, career, family, and health. Then, it adopts funny and inspired voice to transmit messages to encourage and hint user. The system also provides the function of security using infrared sensors and third-generation (3G) mobile phone unit for local or remote monitor. This is useful when a user wants to take a rest, to sleep or remote real-time monitor on private space, then a security mechanism is necessary to implement such a function. Control techniques for temperature, power, etc. can also be built into the system.

In this paper, the system takes account of multi-functional integration, design of healthy entertainment, convenience, and safety. We would describe the design methodology and structure in the following sections. The system has been successfully completed and gets the award in Taiwan.

The rest of this paper is organized as follows. In Section II, the overview of system architecture and methodology is completely introduced. Section III then thoroughly discusses the implementation of proposed novel clock device and summarizes the results. Conclusions are finally drawn in Section IV, along with recommendations for future research.

II. SYSTEM ARCHITECTURE AND METHODOLOGY

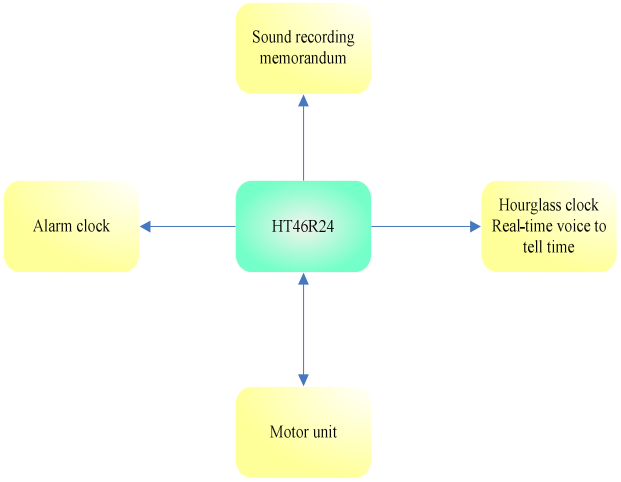
The features of this system are summarized as follows.

1. Innovative design
   - (1) Spherical mouse modeling
   - (2) Novel hourglass clock
   - (3) Unique live round
2. Main alarm clock module
   - (1) Sound recording memorandum unit
   - (2) Hourglass clock model for time display
   - (3) Real-time voice to tell time by infrared control from user
   - (4) Intelligent alarm clock mechanism with four buttons, four LED indicators and motor unit for moving the device at the bottom
3. Lucky module
   - (1) Aromatic unit for comfort
   - (2) The fortune of love, career, family, and health in the live round
   - (3) Funny and inspired voice to transmit messages to encourage and hint user
4. Security module
   - (1) Infrared sensors unit
   - (2) Third-generation (3G) mobile phone unit for remote monitor
   - (3) Alarm for security

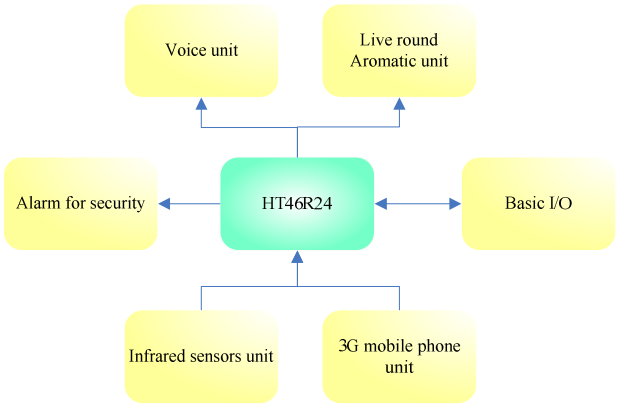
The parts of system architecture and methodology will be described in this section. Then, the parts of physical system architecture will be described in next section

A. Block Diagram

Our proposed system includes two Micro-Controller Units: the first MCU is controlled for the *main alarm clock module* and the second MCU is for the *lucky module, security module and basic I/O control* to command the system start/stop or efficient use of energy. The block diagrams of the proposed system are shown in Figure 1.



(a) The structure of the first MCU



(b) The structure of the second MCU

Figure 1. The complete system architecture

The hardware of system makes use of modularity for easy maintainability in the future. The software of system is developed by C language.

B. Grey Relational Analysis (GRC)

Grey relational analysis is a method for measuring similarity of a reference data to a sequence of data. This analysis scheme is believed to have captured the relationship between the main vector and the other vectors in a given system. Given this feature, grey relational analysis can be applied to relate the reference sequence to the comparison sequences, which can demonstrate the degree of similarity to the reference one, enabling the best comparison sequence can be identified. Therefore, grey relational analysis is an excellent approach for analyzing the similarity of the considered sequences. Let a reference sequence $X_0 = \{x_0(1), x_0(2), ..., x_0(n)\}$ with m comparative sequences $X_i = \{x_i(1), x_i(2), ..., x_i(n)\}$, $i = 1,2,...,m$, be represented as [5][6][7][10][11].

$$X_{comp} = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_m \end{bmatrix} = \begin{bmatrix} x_1(1)\, x_1(2) \cdots\ x_1(n) \\ x_2(1)\, x_2(2) \cdots\ x_2(n) \\ \vdots \quad \vdots \quad \ddots \quad \vdots \\ x_m(1)\, x_m(2) \cdots x_m(n) \end{bmatrix} \tag{1}$$

We can compute the absolute deviation of the reference sequence X_0 to the ith comparative sequence X_i by

$$\Delta x_i(k) = \left| x_i(k) - x_0(k) \right| \quad i = 1,2,\ldots,m, \quad k = 1,2,\ldots,n \tag{2}$$

The deviation matrix ΔX can be represented by

$$\Delta X = \begin{bmatrix} \Delta X_1 \\ \Delta X_2 \\ \vdots \\ \Delta X_m \end{bmatrix} = \begin{bmatrix} \Delta x_1(1)\, \Delta x_1(2) \cdots\ \Delta x_1(n) \\ \Delta x_2(1)\, \Delta x_2(2) \cdots\ \Delta x_2(n) \\ \vdots \quad \vdots \quad \ddots \quad \vdots \\ \Delta x_m(1)\, \Delta x_m(2) \cdots \Delta x_m(n) \end{bmatrix} \tag{3}$$

The grey relational coefficient between X_0 and X_i at the k-th state is defined as follows [5][6][7].

$$c(x_0(k), x_i(k)) = \frac{\Delta x_{\min} + \xi \cdot \Delta x_{\max}}{\Delta x_i(k) + \xi \cdot \Delta x_{\max}} \quad (4)$$

where $c(x_0(k), x_i(k))$ is termed as the grey relational coefficient, k=1,2,…,n, $\Delta x_i(k) = |x_0(k) - x_i(k)|$, $\xi \in (0,1]$ denotes the distinguishing coefficient to control the resolution between $\Delta x_{\max}$ and $\Delta x_{\min}$, $\Delta x_{\max} = \max_{\forall i} \max_{\forall k} \Delta x_i(k)$, and $\Delta x_{\min} = \min_{\forall i} \min_{\forall k} \Delta x_i(k)$. By this definition, each grey relational coefficient satisfies the scope of $0 < c(x_0(k), x_i(k)) \le 1$. The distinguishing coefficient $\xi \in (0,1]$ affects the magnitude of grey relational coefficients without changing the relative relationships of comparative patterns. The selection of the distinguishing coefficient is a numerical consideration. If the difference between $\Delta_{\max}$ and $\Delta_{\min}$ is large enough, the coefficient $\xi << 1$ can be selected to make the grey relational coefficients more distinguishable [10]. Therefore, $\xi = 0.1$ is chosen in this study. The grey relational coefficients are inversely proportional to the error of desired and actual output as defined in equation (4). The grey relational coefficient defined in Equation (4) not only reflects the relation between the target and the actual output sequences, but also shows the degree of output error at the *k*-th state. Because both $\Delta x_{\max}$ and $\Delta x_{\min}$ are constant values for the model in a single comparison sequence.

Once all grey relational coefficients are determined, their weighted average, termed as grey relational grade(GRG) of the reference sequence to the *i*th comparative sequence, can be calculated by

$$g(x_0, x_i) = \sum_{k=1}^{n} [w_k \cdot c(x_0(k), x_i(k))] \quad (5)$$

where w_k denotes the weighting factor of the grey relational coefficient $c(x_0(k), x_i(k))$ and $\sum_{k=1}^{n} w_k = 1$. Generally, $w_k = 1/n$ is selected for all *k*. Hence, each grey relational grade will be within the scope of $0 < g(x_0, x_i) \le 1$.

The grey relational analysis satisfies the following axioms:

(A1) *Norm Interval* : $c(x_o(k), x_i(k)) \in (0,1]$, $\forall k$.
$c(x_o(k), x_i(k)) = 1$, iff $x_o(k) = x_i(k)$, $\forall k$.
$c(x_o(k), x_i(k)) = 1$, iff $x_o, x_i \in \phi$.

(A2) *Duality Symmetric* : $c(x_o(k), x_i(k)) = c(x_i(k), x_o(k))$,
iff $\mathbf{x} = \{x_o, x_i\}$.

(A3) *Approachability* : $c(x_o(k), x_i(k))$ decreases along with $\Delta(k)$increasing,
where $\Delta(k) = |x_o(k) - x_i(k)|$.

(A4) *Wholeness* : $c(x_o(k), x_i(k)) \neq c(x_o(k), x_j(k))$ almost always,
iff $i \neq j$ *and* $m \ge 2$.

By the above description, grey relational coefficient(GRC) and grey relational grade(GRG) are two effective parameters for analyzing the differences and similarity measures of actual outputs and target outputs for input states in the model.

C. GRC for Alarm Clock Module

A novel hourglass clock model for time display is depicted in Figure 2.

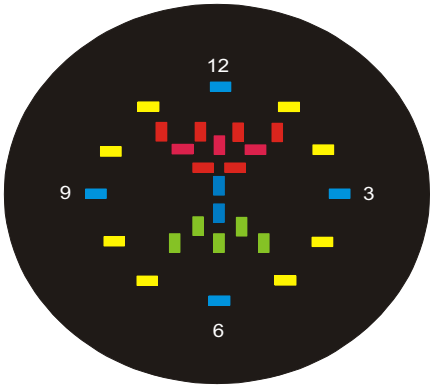


Figure 2. Hourglass clock model

In Figure 2, we originally design twelve LEDs to represent hours around the circle and easily understand. In the center part, we design nine red LEDs to represent 1,2,..,9 minutes respectively, two glistening blue LEDs to represent the variation of second, and five green LEDs to represent 10,20,30,40,50 minutes individually. In additional, we design real-time voice to tell time by infrared control from user, and two times of special hourglass show with bright variation of LEDs in each minute.

The intelligent alarm clock mechanism is combined in the hourglass clock model with four buttons, four LED indicators and motor unit for moving the device at the bottom. When user had set alarm clock complete and alarm clock time has been out, the intelligent mechanism would start alarm voice by sound recording memorandum unit, move the device by motor unit, and run random four LED indicators with four buttons. A user has to correctly press the button with the mapping LED indicators for stop of alarm clock. Our purpose is to wake up user effectively. The algorithm based on grey relational analysis is described as follows.

GRC algorithm for alarm clock is summarized as the following steps:

1) Initialize the memory contents with zero value and assign necessary parameters: $\xi = 0.1$, r[ ] with random sequence for the variation of LED indicators.
2) Depend on the differences of actual outputs from user press the button with the mapping LED indicators and target outputs to determine **GRC** and **GRG** in each five seconds.
3) If (**GRG** <= 0.5) then slow down the variation of LED indicators.
4) If the assigned termination criterion is not satisfied, then go to step2; Else stop alarm clock;

D. Hashing Function for Lucky Module

Innovative design of live round is depicted in Figure 3. We create a unique structure of live round according to the medical theory of psychology and hashing function for randomization. In the live round, it has aromatic unit for comfort and can determine the fortune of four fields, including

love, career, family, and health. Then, it adopts funny and inspired voice to transmit messages to encourage and hint user. Live round takes advantages of special bright variation of LEDs and the visual effect (like the firework of national festival) to make people feel better, relieve the stress and achieve the result of relaxation. We adopt many kinds of high-lighted LEDs to configure the live round. In the live round, it includes a test that is termed today's fortune. The user can select a state (bad, normal, good, very good) in the external circle with love, career, family, health respectively, then press start button. The system would generate a mapping state by hashing function in the internal circle. The difference of two states in the external and internal circle is used to point out today's fortune, including love, career, family, health respectively. The more the disparity is, the worse the fortune will get, on the contrary, the little the difference is, the better the fortune will be.

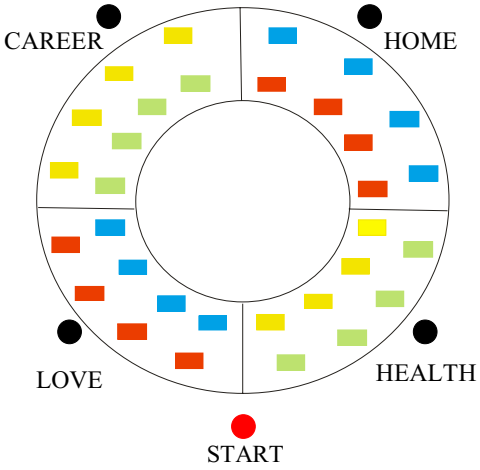


Figure 3.The structure of live round

Today's fortune in the live round adopts hashing function that is defined as follows.

Step1. When start button is pushed down, system would get a count from clock counter.

Step2. Assign x=count; r[ ] with random sequence;

Using hashing function by division:

$$a=H(x)= x \bmod s \quad (6)$$

where $s=4^4=256$ is total states in this paper.

a1= r[a*4]

a2= r[a*4+1]

a3= r[a*4+2]

a4= r[a*4+3]

a1, a2, a3, and a4 are individual states of love, career, family and health.

E. Security Module

The system also provides the function of security using infrared sensors and third-generation (3G) mobile phone unit for local or remote monitor. This is useful when a user wants to take a rest, to sleep or remote real-time monitor on private space, then a security mechanism is necessary to implement such a function. Control techniques for temperature, power, home automation, etc. can also be built into the system.

III. System Implementation

Physical structure with spherical mouse modeling is depicted in Figure 4 and Figure 5. In this paper, a novel consumer alarm clock device includes the following units.

1. Hourglass clock model (Real-time voice to tell time)
2. Live round
3. Aromatic unit
4. Voice unit
5. Alarm clock
6. Basic I/O unit
7. Motor unit
8. Infrared sensors unit
9. Sound recording memorandum unit
10. Third-generation (3G) mobile phone unit for remote monitor

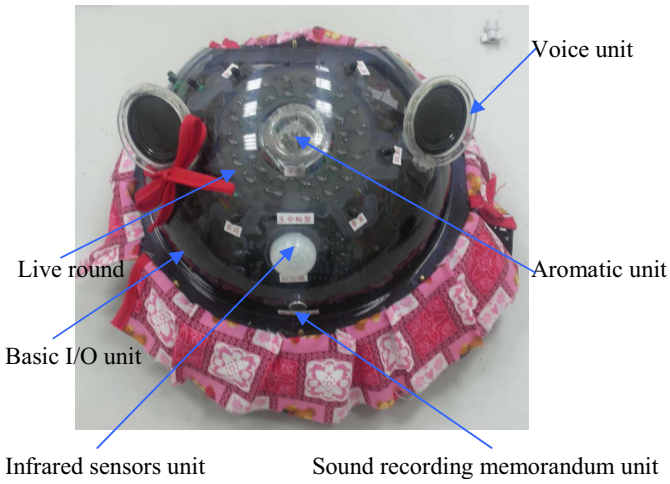


Figure 4. The front of physical structure

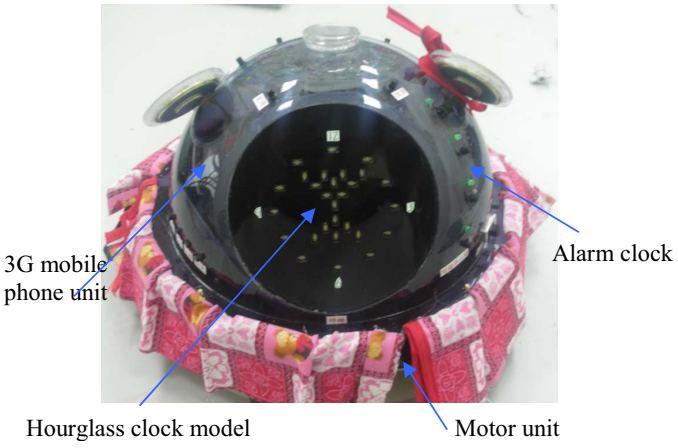


Figure 5. The rear of physical structure

IV. Conclusion

This paper proposes an alarm clock device which is a novel spherical mouse modeling by incorporating main alarm clock module, lucky module and security module. In the main alarm clock module, we design a novel hourglass clock model for time display, sound recording memorandum unit and intelligent alarm clock features to wake up user effectively based on GRC algorithm. In the lucky module, we create a unique structure of live round according to the medical theory of psychology and hashing function for randomization. In the live round, it has aromatic unit for comfort and can determine the fortune of four fields, including love, career, family, and health. Then, it adopts funny and inspired voice to transmit messages to encourage and hint user. The system also provides the function of security using infrared sensors and third-generation (3G) mobile phone unit for local or remote monitor. This is useful when a user wants to take a rest, to sleep or remote real-time monitor on private space, then a security mechanism is necessary to implement such a function. The system has been successfully completed and gets the award in Taiwan. Related control techniques for temperature, power, home automation, etc. can also be built into the system. These will be done in the near future.

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