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Device Development and Firmware Programming for Vitamin D Management

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Abstract

Lack of outdoor activities, and the use of sunscreen, low sunlight causes vitamin D deficiency. Lack of vitamin D can lead to bone disease, diabetes, muscle strength and cardiovascular disease. This study measures the amount of sunshine for each individual and establishes a management system that applies the amount of insufficient sunshine. Firmware programming is important for this operation. In this study, we improved the efficiency by using scheduling method.

Keywords*: Sunlight, Vitamin D, UV Index, Cortex-M4.*

1. INTRODUCTION

Modern people lack outdoor activities, lack of sunshine, which is reducing the amount of vitamin D synthesis. Deficiency of the synthesis of vitamin D is vulnerable to various diseases. Some of the abnormalities that can occur in our body when vitamin D is deficient are as follows. Less calcium absorption can lead to bone and muscle pain and osteoporosis [1]. It also affects serotonin synthesis, which can lead to seasonal depression and can lead to body aging, obesity, diabetes, and cardiovascular disease. According to the 2013 Health Insurance Review and Assessment Service, 86.9% of men in Korea and 93.3% of women show vitamin D deficiency. Because women are expected to experience rapid bone loss after menopause, bone loss in the 20s can be fatal with age, so the synthesis of vitamin D is more important for women copyright form and the form should accompany your final submission.

2. RELATED RESEARCH

2.1. Relationship between vitamin D and sunshine

Vitamin D is divided into D2 and D3. Vitamin D3 is synthesized in the basal layer of skin when exposed to the sun, and vitamin D2 is a compound synthesized by stimulating vegetable sterols with ultraviolet rays. Vitamins D2 and D3 differ in metabolic processes and differ in their ability to bind to, or affinity for, vitamin D-binding proteins and their ability to move into the circulation. Recent studies report that vitamin D3 is more potent than D2. in the liver [3] [4]. Vitamin D is synthesized in the body through food and the sun.

Thus, synthesized vitamin D is broken down into 25 (OH) D by 25-hydroxylase. Vitamin D consumed by food meets vitamin D produced by skin cells through UV-B and is activated by enzymes in the liver and kidney.

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2.2. Effects of Ultraviolet Rays on Vitamin D in Sunlight

Sunlight is very important to all living things, including humans. Infrared light keeps you warm, visible light helps you see things with your eyes, and helps plants produce nutrients through photosynthesis. Ultraviolet rays produce vitamin D in human skin and act as a bactericidal agent. As such, ultraviolet rays are responsible for producing vitamin D. UV rays fall into three categories: UV-A, UV-B, and UV-C. UV-A is not absorbed by the ozone layer. Ultraviolet UV-A, which has a wavelength range of 320-400nm, has less energy than UV-B, but it not only makes the skin open, but also acts on the skin's immune system, which damages the skin in the long term and promotes aging. Longer exposure times of UV-A have been reported to have the same risk of skin cancer as UV-B.When ultraviolet rays reach the human body, they are absorbed below the epidermal layer, triggering human immune action to protect the skin from these harmful rays. For example, some cells produce a black pigment called melanin when it is exposed to ultraviolet light, which absorbs some of the ultraviolet light. Thus, people who produce less melanin, like Caucasians, also have less natural protection against UV-B. Most of UV-B is absorbed by the ozone layer, but some reach the earth's surface. UV-B, which reaches very small amounts of earth, is ultraviolet light with a wavelength range of 280-320 nm. UV-B burns animal skin, penetrates skin tissue, and sometimes causes skin cancer. The cause of skin cancer is most often associated with sun exposure and UV-B.UV-B also activates provitamin D in the skin and converts it into vitamin D, which is essential for the human body. UV-C is completely absorbed by the ozone layer. UV-C among ultraviolet rays with a wavelength range of 100-280nm causes harmful effects on life, causing chromosomal variation, killing single-celled organic matter, and damaging the cornea of the eye. Fortunately, ultraviolet rays in this range, known as UV-C, are absorbed almost entirely by the stratospheric ozone.Based on this fact, vitamin D is synthesized by ultraviolet light. It can be seen that it is synthesized due to UV-B.

2.3. Effect on human body by UV Index

The effect on the human body depends on the UV level, that is, the UV Index. When exposed to the right time, the body can synthesize vitamin D. However, prolonged exposure can cause skin cancer. This was classified and presented by the World Health Organization (WHO).

Table 1. Global solar UV index:

Exposure category	UVI Range
Low	< 2
Moderate	3 TO 5
High	6 TO 7
Veryhigh	8 TO 10
Extreme	11+

In terms of UVI, 0 to 2 are indices that do not require special measures due to their low UV intensity. 3 ~ 5 is a clear summer season, but it is a bit cloudy and may cause cumulative skin erythema after long exposure. 6-7 are not light levels. Protect your eyes and skin when you go out. 8 ~ 10 is an index that requires skin protection measures because the UV intensity is very strong on sunny days in summer. In particular, 11 am to 1 pm should not go out. 11 or more rarely come out of Korea, but it is good to refrain from going out. UVI, which the body can produce vitamin D, synthesizes when vitamin D is above 3. UV-B can't pass through windows and can produce vitamin D only outdoors, not indoors.

2.4. Differences in Recommended Vitamins by Age

UV-B, which synthesizes vitamin D, irradiates 1 solar SED to hands and face, increasing 1 nmol of 25 (OH) D. Referring to Table 1, 1 nmol

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equals 100 IU of the daily dose of vitamin D3 [5].

Table 2.25 (OH) D concentrations according to vitamin D3 dosage

Vitamin D3 Daily Dose	Increasing dose of 25 (OH) D
100 IU	1ng/mL
200 IU	2ng/mL
400 IU	2ng/mL
800 IU	8ng/mL
1000 IU	10ng/mL
2000 IU	20ng/mL

Vitamin D3 is metabolized to 25-Hydroxyvitamin D (25 (OH) D3) in the blood in the liver, and this 25 (OH) D3 is a substance used to assess the state of vitamin D in the body.

Vitamin D is an inactive type that is produced by the sun from the skin, taken from supplements, or stored normally in the liver. This is because the liver changes to intermediate activator 25 (OH) D as needed every day. The minimum recommended daily dose according to age created according to the latest US Endocrine Society clinical application guidelines is shown in Table 2. It can be seen that the amount of vitamin D required varies with age. In particular, when looking at children and the elderly (70 years old or older), the minimum recommended daily dose is about 1.5 to 2 times the difference.

Table 3. Recommended vitamin D by age

Age of Subject	Daily recommended amount	Daily maximum amount
0~6 months	400 IU	1000 IU
6~12 months	400 IU	5000 IU
1~3 years old	600 IU	2500 IU
4~8 years old	600 IU	3000 IU
9~13 years old	600 IU	4000 IU
14~18 years old	600 IU	4000 IU
19~30 years old	600 IU	4000 IU
31~50 years old	600 IU	4000 IU
51~70 years old	600 IU	4000 IU
Over 70 years old	800 IU	4000 IU

3. METHODOLOGY

The criteria for the system are selected by measuring the actual indoor and outdoor UVI. It also calculates the necessary vitamin D according to age and associates the UVI to implement the system

3.1. Indoor and Outdoor UVI Measurement

This measurement was performed at 2 pm in the open air, and only UV-B needed was measured by using an ultraviolet sensor (SI1145) for measuring UVI designated by WHO. Indoor measurements were taken with fluorescent lights in rooms with windows.

3.2. Average time selection for sunshine

When analyzing the graph by referring to the simple regression equation of vitamin D and sunshine amount referring to the previous theory and the preceding study, it is necessary to receive about 200 ~ 250 minutes of sunshine amount for a week to show the value of vitamin D concentration over 20ng / mL. It is concluded that The result is a calculation that averages 28 to 35 minutes per day.

3.3. Average time of sunshine according to age group

Based on Table 2, the study represents 400 IU for a daily minimum dose of 0-12 months and 600 IU for ages 1-70. Over 70 years old is 800 IU. This is the minimum recommended amount, which is classified as 400IU for children aged 0 to 18 years, and 600IU for adults aged 19 to 70 and 800IU for elderly people over 70 years. Refer to 3.2 of the study contents and methods, since 30 minutes were standardized for normal healthy adults, this is based on 600 IU for adults aged 19 to 70 years. When calculating this, children are 20 minutes because of 400IU, 40 minutes because of 800IU.

Table 4.UVI time required by age group

Age	Vitamin D Minimal amount	Time required (minutes)
Children	400IU	20
adult	600IU	30
elderly	800IU	40

3.4. System

The values set in the system implemented in this study are as follows.

Table 5. Stack setting value according to UVI

UVI	Time required (minutes)	Stack setting value
0~2	Infinite (Meaningless)	0
3~5	30	1
6~7	30	1
8~10	15	2
11	Alarm (Too much)	

Two types of ultraviolet sensor SI1145 and illuminance sensor AP3216 are used to measure sunlight. The Ambient Light Sensor AP3216 reads all wavelengths of ultraviolet light and outputs the full amount of light.

The UV sensor SI1145 divides the area according to the UVI designated by the WHO. In addition, note that we only measure the UV-B we want. When calculating the value referring to (Table.4), if the UVI corresponding to the stack value 1 is accepted for 30 minutes, make sure that it is fully charged. At this time, the stack value is accepted per second and is fully charged when 30 minutes or 1800 stack values 1 are received. Since this is also an adult standard, the value of full charge for children and the elderly is changed. At this time, if the UVI is more than “11”, the red LED is turned on and warns the user with a buzzer sound.

The UV sensor accepts UVIs divided in stages. By using the levels of the accepted UV Index, different stack values are given for each level so that the user can see how many UV-Bs he received at the desired time. It is formulated in the Cortex MCU and receives the information of insufficient UV-B to compensate for the insufficient amount through a device that applies UV. Too much UV-B can cause problems such as skin cancer, so accurate measurement and device irradiation times are very important.

It is difficult for the user to understand the exact meaning when outputting the value charged to the display directly. Therefore, the current charge value is output as a percentage (%) divided by the total charge value for one day according to the age group. When implementing the system, for the convenience of the user, when the 21 o'clock comes as a notification device, the display screen shows the stack value

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accumulated today. At 22:00, all stack values are initialized to zero.When the IR remote is used in conjunction with Cortex MCU, the value that Cortex MCU reads the remote's signal is displayed as the specific hexadecimal promised, so it is necessary to make the decimal representation for the user's convenience. This can be solved with code features. The remote can enter user information and code initialization and confirmation settings.RTC (Real Time Clock) was used for time accuracy. The function of this sensor is to save the time interlocked with the computer when the initial Cortex MCU code is uploaded, and to save the time in real time using the RTC internal power without additional power.

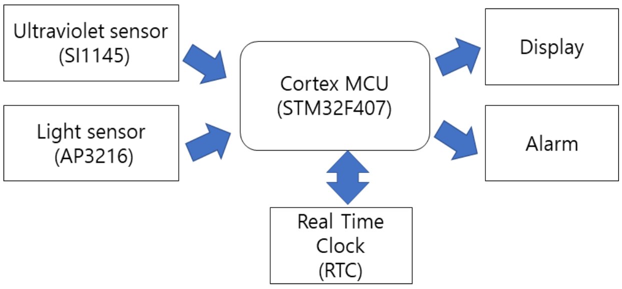

Figure 1: System Configuration

3.5. Firmware programming

Based on the value received from the sensor, the UVI was converted and firmware programmed to compensate for the required UV.

```
float Fullcharge1=4800000;
float Fullcharge2=7200000;
float Fullcharge3=9600000;
float Mycharge=0;
```

This is the declaration of the above coding. In adult standards, 30 minutes is 7200 for every 0.5 seconds of UVI. In addition, as mentioned earlier, Vis multiplies the number of infrared rays by 1000 based on the average weather, and the value of full charge is 7200000. C, children and the elderly were calculated.

```
void UVcalc(){
if(UVindex<3){
Mycharge=Mycharge;
}else if(UVindex>=3 &&UVindex<8){
Mycharge=Mycharge+uv.readVisible()*1;
}else if(UVindex>=8 &&UVindex<11){
Mycharge=Mycharge+uv.readVisible()*2;
}else if(UVindex>=11){
Mycharge=Mycharge;
}}
void Agecalc(){
if(AgeGroupflag==1){
Todaypercent=20-Mycharge/Fullcharge1*20;
}else if(AgeGroupflag==2){
Todaypercent=30-Mycharge/Fullcharge2*30;
}else if(AgeGroupflag==3){
Todaypercent=40-Mycharge/Fullcharge3*40;
} }
```

The above coding is the main function. UVcalc () breaks down the UVIs. The Agecalc () is a function that subtracts the Mycharge value received from the full charge value to the percentage (%) from the time classified as children, adults, or the elderly. This is shown as a percentage on the display [6-8].

Vis is the amount of UV light, UVIndex is UVI, IR is infrared intensity, and ALS is the brightness of light itself. Other data is attached as an appendix. Based on this, it can be seen that when the UVI is 3 or more, it is determined that less than 3 are indoors.

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4. RESULTS

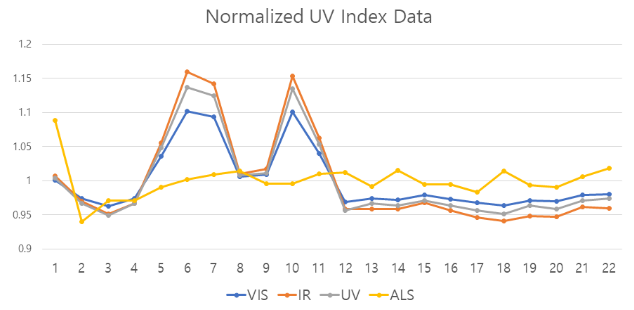

Figure 2: Normalized UV Index data

Table 6. Average values of measured VIS, IR,CV,ALS

VIS	IR	UV	ALS
1011.818	6460.727	4.045909	38608

Figure above was a qualified for the VIS, IR, CV, ALS measured using this system.This is because the magnitude of each value is relatively different. We normalized because we wanted to see a change in the value.

The table below shows the actual measured values

Table 7. Measured VIS, IR,CV,ALS values

VIS	IR	UV	ALS
1013	6504	4.06	38608
986	6266	3.91	33337
974	6145	3.84	34443
986	6244	3.91	34437
1048	6820	4.24	35138
1115	7489	4.60	35529
1107	7380	4.55	35811
1018	6527	4.08	35982
1021	6572	4.09	35325
1114	7454	4.59	35336
1052	6864	4.26	35843
980	6196	3.87	35904
986	6196	3.91	35191
984	6191	3.90	36013
991	6253	3.93	35287
985	6180	3.90	35272
979	6116	3.87	34869
975	6079	3.85	35992
982	6128	3.90	35259
981	6122	3.88	35131
991	6210	3.93	35686
992	6200	3.94	36121

5. CONCLUSION

These days, lifestyles change and there is absolutely no time to take sunlight. Adults spend a day in the office, and children spend most of their time indoors, such as school classrooms, academy, or home. There is no time to sunshine outside, except for school and rush hours. Many people think that having enough sunlight indoors through the window will help the synthesis of vitamin D. In the middle of the UVB, which affects the synthesis of vitamin D3, UVB does not penetrate the window. It should be exposed directly to the exposed state.

In Korea, because of the lack of sunshine in winter and the lack of outdoor activities usually, vitamin D supplements are often taken. Therefore, as exemplified in this study, it is thought that vitamin D deficiency can be prevented by measuring the amount of sunshine and supplementing the insufficient amount with UV.

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