SMART HEALTH BRACELET FOR EDUCATIONAL INSTITUTIONS

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PROBLEM STATEMENT

In today's world sudden illnesses are caused by various viruses, ex. the worldwide COVID-19 is becoming more common. In many cases, it can lead to hospitalization and even death. People are at high risk to be contaminated especially when they are in public places such as educational institutions or office-type companies.

In order to anticipate or prevent these cases, it is necessary to provide annual medical examinations for employees and monitor their health every day. Much more important is the monitoring of the human condition in real time.

SOLUTION

It is necessary to determine the basic person's physical condition parameters and effectively make decisions based on the data obtained. To do this, for example in educational institutions, a device similar to modern fitness trackers or smart watches can be used.

This device has to be constantly on the student's hand and to monitor vital functions such as body temperature, saturation level (oxygen saturation) and heart rate. The development of this device is very important in reality.

ADVANTAGES

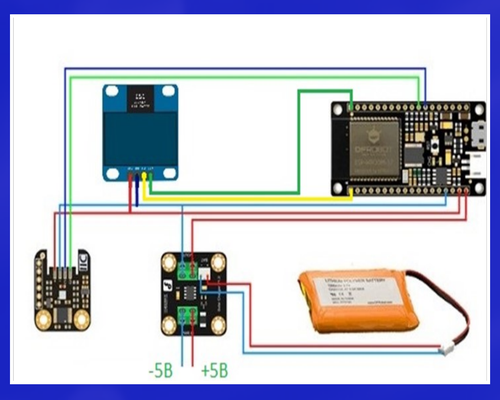
- ◊ According to the information analysis, no analogues of such developed device has been founded. Modern fitness trackers or smart watches define single human condition parameters. None of the above ones makes a conclusion about general human condition.
- ◊ The developed mathematical model indicates user`s general physical condition taking into account main human condition parameters and has a high level accuracy.
- ◊ The developed mathematical model operates on the self-learning principle in real time.
- ◊ The developed device and server decision making technology can be used not only in educational institutions but in many other organizations.

HARDWARE IMPLEMENTATION

SENSORS AND COMPONENTS

- ◊ Microcontroller Arduino Nano (possibly ESP 32 in further versions)
- ◊ Temperature sensor Lm—35 (possibly AHT 10 in further versions)
- ◊ Pulse oximeter MAX 30102
- ◊ Screen Oled 128x64
- ◊ Battery Li-pol 402030

Bracelet casing developed 3D-model



Components connection

MATHEMATICAL MODEL FOR THE USER'S GENERALIZED PHYSICAL CONDITION INDICATOR

$$Z = c_0 * T^{c_T} * H^{c_H} * S^{c_S} * \varphi^{c_\varphi},$$

Here:

Z — user's generalized physical condition indicator;

T — temperature, ^{0}C;

H — heart rate, beats per minute;

S — saturation, %;

ϕ — skin moisture, %;

c_0, c_T, c_H, c_S, c_ϕ — mathematical model coefficients.

MATHEMATICAL MODEL COEFFICIENTS MATRIX CALCULATIONS (EXAMPLE)

Sensors data

№	Temperature	Heart rate	Saturation	Skin moisture
1	33	88	89	91
2	36	91	89	98
3	32	89	88	96
4	32	87	89	89
5	33	100	71	88
6	31	86	88	76
7	30	73	85	85
8	26	79	96	83
9	35	93	89	91
10	33	96	91	90

```
factor=log(factor)//factor coefficients calculation
Z=log(Z)
A=[1,0,0,0,0
    0,0,0,0,0
    0,0,0,0,0
    0,0,0,0,0
    0,0,0,0,0]
B=[0;0;0;0;0]
for j=1:int(length(factor)/4)
  A(1,2)=A(1,2)+factor(j,1)/int(length(factor)/4)
  A(1,3)=A(1,3)+factor(j,2)/int(length(factor)/4)
  A(1,4)=A(1,4)+factor(j,3)/int(length(factor)/4)
  A(1,5)=A(1,5)+factor(j,4)/int(length(factor)/4)
  A(2,1)=A(1,2)
  A(2,2)=A(2,2)+factor(j,1)^2/int(length(factor)/4)
  A(2,3)=A(2,3)+factor(j,1)*factor(j,2)/int(length(factor)/4)
  A(2,4)=A(2,4)+factor(j,1)*factor(j,3)/int(length(factor)/4)
  A(2,5)=A(2,5)+factor(j,1)*factor(j,4)/int(length(factor)/4)
  A(3,1)=A(1,3)
  A(3,2)=A(2,3)
  A(3,3)=A(3,3)+factor(j,2)^2/int(length(factor)/4)
  A(3,4)=A(3,4)+factor(j,2)*factor(j,3)/int(length(factor)/4)
  A(3,5)=A(3,5)+factor(j,2)*factor(j,4)/int(length(factor)/4)
  A(4,1)=A(1,4)
  A(4,2)=A(2,4)
  A(4,3)=A(3,4)
  A(4,4)=A(4,4)+factor(j,3)^2/int(length(factor)/4)
  A(4,5)=A(4,5)+factor(j,3)*factor(j,4)/int(length(factor)/4)
  A(5,1)=A(1,5)
  A(5,2)=A(2,5)
  A(5,3)=A(3,5)
  A(5,4)=A(4,5)
  A(5,5)=A(5,5)+factor(j,4)^2/int(length(factor)/4)
  B(1,1)=B(1,1)+Z(j)/int(length(factor)/4)
  B(2,1)=B(2,1)+factor(j,1)*Z(j)/int(length(factor)/4)
  B(3,1)=B(3,1)+factor(j,2)*Z(j)/int(length(factor)/4)
  B(4,1)=B(4,1)+factor(j,3)*Z(j)/int(length(factor)/4)
  B(5,1)=B(5,1)+factor(j,4)*Z(j)/int(length(factor)/4)
end
factor_Z=linsolve(A,-B)
```

Listing of program code for the developed mathematical model coefficients basic values calculation in the applied mathematical programs package SciLab 6.1.1

Results: matrix of mathematical model coefficients

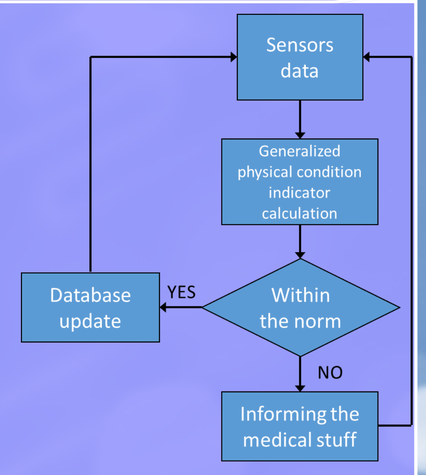
Parameter		Skin temperature, ^{0}C	Heart rate, beats/min	Skin moisture, %	Saturation, %
Average value		32	80	50	94
Standard deviation		0,5	9	2,4	0,6
Parameter's allowable ranges	Minimum	31,5	71	47,6	93,4
	Maximum	32,5	89	52,4	94,6
Normal distribution function value	Minimum	0,484	0,027	0,101	0,403
	Maximum	1	1	1	1
The generalized person's physical condition indicator's limits	Minimum	0,254			
	Maximum	1			
c_0		c_T	c_H	c_φ	c_S
0,325		-0,196	0,437	0,324	-0,120

FURTHER DEVELOPMENT AND IMPLEMENTATION

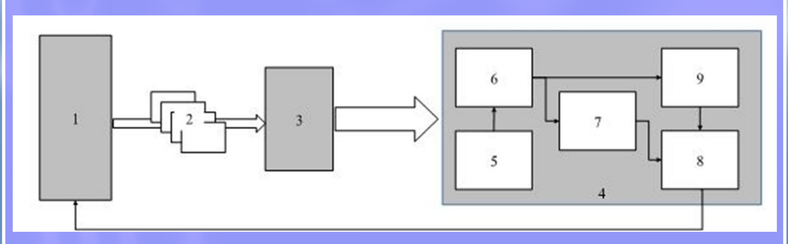
- ◊ In further versions it is possible to change microcontroller according to its small memory amount and efficiency and to replace the chosen sensors into some parameters according to their accuracy level.
- ◊ In case the matrix method for mathematical model calculation does not satisfy the speed performance needed, the neural networks technology can be used.
- ◊ The developed device can be used not only for educational or medical institutions but also for drivers, rescuers, office employees, and people of many other professions and also for personal health monitoring.

MATHEMATICAL MODEL SOFTWARE IMPLEMENTATION

Principal algorithm scheme:



Global principal scheme:



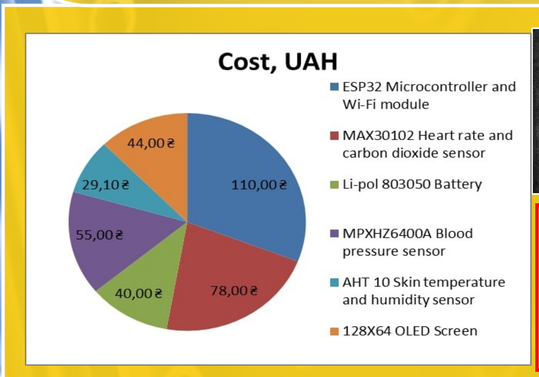
1. User wearing the developed bracelet;
2. Data from bracelet's sensors;
3. Mobile application;
4. Web server;
5. Database;
6. Person's generalized physical condition indicator calculation module;
7. Medical stuff informing about some person's health deviations;
8. Data update.

Technologies used:

ARDUINO OPEN-SOURCE COMMUNITY

C++

BUSINESS MODEL FOR THE DEVELOPED DEVICE



Producer → Wholesaler → Retailer → Consumer

Branch: **electronics and instrumentation**

Consumer: **educational institutions, that will purchase devices and software**

The final product: **a smart bracelet**

CONCLUSIONS

- ◊ The main health condition indicators, which are informative for the real time human physical condition monitoring are defined.
- ◊ The generalized human physical condition indicator mathematical model on the basis of defined indicators is developed.
- ◊ The smart bracelet prototype has been created to measure the user's health parameters and monitor his physical condition in real time.
- ◊ The human condition monitoring pilot experimental study on the basis of the developed device has been conducted.
- ◊ Ways of the device's possible improvement and further researches directions are defined.