Comparison of Techniques for Color Identification in Fluids

Danielly Moraes Pereira
Instituto SENAI de Inovação
ISI Microeletrônica
Manaus, Brazil
daniellymoraes.dm@gmail.com

Raphael Vasconcelos Nunes de Mello
Instituto SENAI de Inovação
ISI Microeletrônica
Manaus, Brazil
raphaelvnmello@hotmail.com

Carlos R. P. dos Santos Junior
Instituto SENAI de Inovação
ISI Microeletrônica
Manaus, Brazil
carlos.pereira@am.senai.br

Carlos Kenneton Rocha de Almeida
Instituto SENAI de Inovação
ISI Microeletrônica
Manaus, Brazil
carlos.almeida@am.senai.br

Valtemar Fernandes Cardoso
Instituto SENAI de Inovação
ISI Microeletrônica
Manaus, Brazil
valtemar.cardoso@am.senai.br

Marcus Vinicius Pelegrini
Instituto SENAI de Inovação
ISI Microeletrônica
Manaus, Brazil
marcus.pelegrini@am.senai.br

***Abstract*— Photometric methods are used to determine concentrations of chemical substances, these methods can also be used to discover blood diseases in humans and animals. The practical study to test several sensors is necessary to improve the devices that perform these analyzes. In order to make these comparisons, three prototypes were developed, each one having a different configuration, the three sensors used were a LDR, Red LED and a TCS230 color sensor. Among the three techniques analyzed, it was observed that the methodology using an LED as a color detector was more efficient.**

***Keywords* — LDR, TCS230, Color Identification, LED, Fluids**

I. INTRODUCTION

The amount of water contained in the body of an adult human is equivalent to approximately 60% of its body mass [1]. Many of these liquids, such as blood, urine and other secretions, may undergo color changes that may indicate a system's malfunction. Human urine, for example, if present red color may indicate medical conditions like Porphyria, Urinary bladder malignancy and prostrate malignancy [2].

This phenomenon also happens with animals such as cattle, the normal coloration of bovine urine varies between light yellow and light dark, if urine is colorless, it is possible that there is increased excretion, acetonemia or severe renal insufficiency, and yellow gold reduction of diuresis that occurs in severe general disorders or febrile illness. Urinalysis is considered an important tool for veterinarians to diagnose, mainly of subclinical disorders [3].

In a study on infant mortality shows that the mothers of the children claimed that some of them had symptoms such as green diarrhea or with the appearance of blood and yellow vomit with blood [4].

It is possible to improve the process of detecting the colors of liquids through the use of sensors, one of the advantages of this application is that they allow the recognition of a larger number of samples in a shorter time. Furthermore, automatic color detection mechanisms avoid the subjectivity of the interpretation of the human eye, thus improving the accuracy of the procedure [5].

It is possible to develop new color detection techniques with more accessible light-sensitive elements such as LDR (Light Dependent Resistor) and LED (Light Emitting Diode).

This paper demonstrates the construction and comparison of three components for color detection, using as an element sensitive to brightness an LED, an LDR and the photodiode matrix of the TCS230 Color sensor.

II. MATERIALS AND METHODS

In this topic the set of components and the assembly of each sensor will be presented, and the operation of the data acquisition will be described. In the end the methods used for the development of the three color detecting components will be described.

A. Components

The LDR (Light Dependent Resistor) is a resistor that varies its value according to the intensity of light incident on it. The greater the intensity of the luminosity, the more free electrons it will have and the less its resistance [6].

The LED (Light Emitting Diode) is a semiconductor, which has the ability to transform energy into light. It is a bipolar component that has an anode and a cathode that when polarizing allow the passage of current, which generates luminosity. The LED can be operated bidirectionally and can be connected to the microcontroller in the input-output (I / O) pins in a reverse way and, therefore, it can be used as a light detector [7].

The TCS230 sensor generates square wave output that contains the frequency directly proportional to the received light intensity. In the middle of the sensor is an 8x8 matrix of photodiodes. Of these photodiodes, 16 have green filters, 16 have red filters, 16 have blue filters and 16 have no filters. The output frequency range and the photodiode type can be configured according to Table 1 [8].

TABLE. 1. SELEC TABLE SENSOR OPTIONS [8].

Pins		Output Frequency Scaling	Pins		Photodiode Type
S0	**S1**		**S2**	**S3**	
LOW	LOW	**Power Down**	LOW	LOW	**Red**
LOW	HIGH	**2%**	LOW	HIGH	**Blue**
HIGH	LOW	**20%**	HIGH	LOW	**Clear (No Filter)**
HIGH	HIGH	**100%**	HIGH	HIGH	**Green**

The Arduino Uno is a board that has, as main component, a microcontroller based on the ATmega328 [9]. With it you can perform specific tasks. It has fourteen pins that can be used as digital inputs or outputs and six analog input pins.

Other components such as a protoboard, resistors, samples with colored liquids, a support and light insulation structure and connecting wires were also used.

B. Methods

Three prototypes were built for color detection, their operation can be summarized as follows: An LED has its light beam directed to the sensor, which is differentiated in each prototype. Between the LED and the sensor there is a zone where the sample is inserted. When the sample is positioned in this zone, it makes a barrier between the LED and the sensor, allowing a certain amount of light to pass. Each color allows the passage of a certain amount of particular light that can be determined.

For the implementation of the color detectors, a structure, shown in Fig. 1, was developed to be used in the three recognizers. It has the function of supporting the samples shown in Fig. 2, isolating the sensors against external illumination, so that there is little interference with it and keep the LED emitter (yellow) that is located inside, more specifically, at the top.

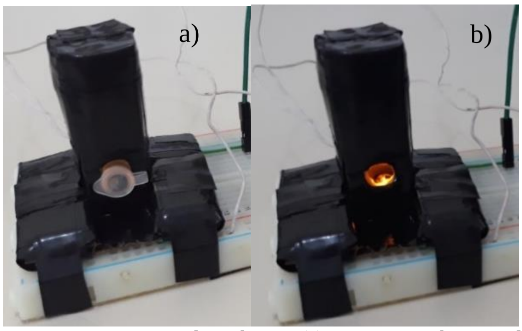

Fig. 1. Support structure and insulation: (a) Structure with a sample inserted. (b) Structure without sample inserted.

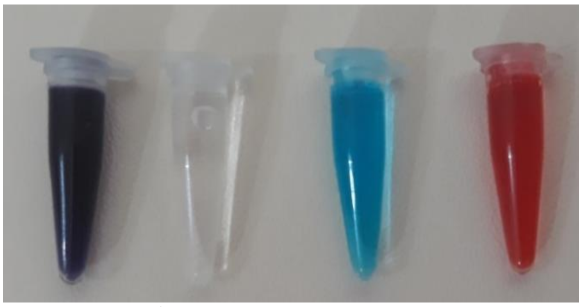

Fig. 2. Samples used for color detection.

B.1 Prototype 1

The next step was to assemble the prototype 1, it consists of the insulation structure, an Arduino UNO, a protoboard, wires for connections, a LED emitter, a resistor of 330Ω, which performs the protection of the emitter LED, a resistor of 10kΩ and an LDR, which is the brightness sensitive element. It is inserted into the protoboard, located at the bottom of the structure, directly receiving the emitting LED beam. The composition of the prototype is shown in Fig. 3. It can be noted that the connection to the Arduino was performed on the 10KΩ Resistor, this could be done because the resistor and the LDR, as they are arranged, form a voltage divider when the changes the value of the LDR, the resistor also changes.

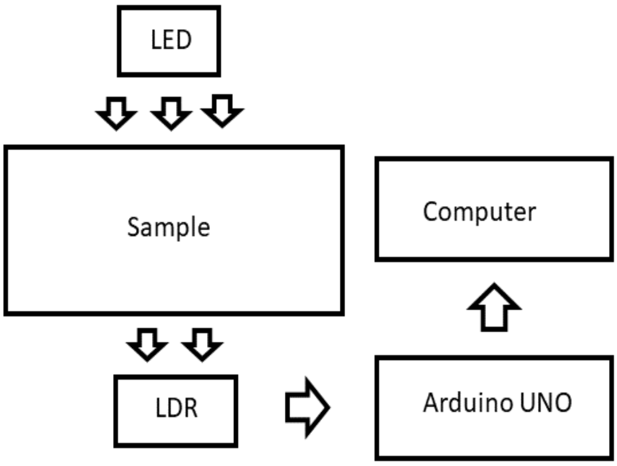

Fig. 3. Prototype 1

After the assembly of the physical circuit, the code was developed and recorded in Arduino. A total of ninety results were analyzed for each sample. Since, for every thirty results, the samples were withdrawn and repositioned in the prototype to verify that a different positioning would interfere with the result. Within the analyzed results, the highest and lowest responses were recorded to define the range of values equivalent to each color. In the software it was defined that a result is the average of ten readings performed by the sensor, to eliminate discrepancies. Ninety results were also obtained for the parameters: clear, without barrier (no sample) and dark, with the emitter LED off.

B.2 Prototype 2

The prototype 2 works similarly to the first one, however, in this case, a red LED was used to measure the brightness. Therefore, it consists of a LED emitter, a 330Ω resistor, an Arduino UNO, a LED receiver (sensor), a protoboard, insulation and support structure and wires for connections. Their assembly can be seen in Fig. 4. The same programming and data acquisition criteria of prototype 1 were repeated for this prototype.

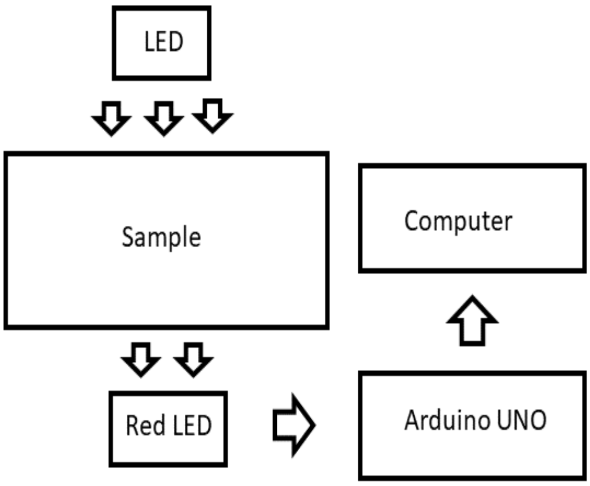

Fig. 4. Prototype 2

B.3 Prototype 3

The prototype 3 consists of the TCS230 sensor, an emitter LED, a 330Ω resistor, an Arduino UNO, an insulation and support structure and wiring for connections. The standard procedure of the TCS230 sensor works as follows: It has four LEDs that emit brightness for the object, this reflects the light beams for the photodiode array located in the center of the sensor that finally sends the received values to the Arduino. However, for this experiment, only the matrix of photodiodes was used to detect the variation of luminosity and the same structure with the emitting LED that is part of the composition of the other prototypes.

In order to fit the structure to the sensor, the base had to be removed, the result of this modification is shown in Fig. 5.

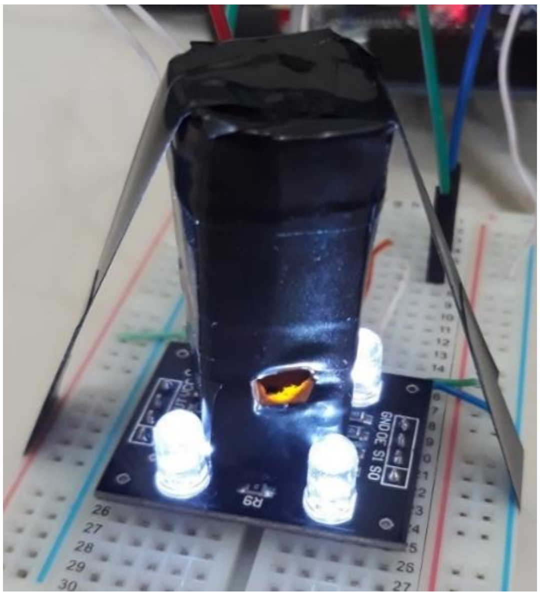

Fig. 5. Structure Prototype 3

Due the sensor has photodiodes with specific filters for each color, the data acquisition of prototype 3 was distinguished from the others. Ninety readings were taken from the samples, from the light and dark to the photodiodes with a red filter, ninety for the photodiodes with a green filter and ninety for the photodiodes with a blue filter, and their frequency scale was set in 20%, with S0 at HIGH and S1 at LOW, as shown in Table 1. At the end, the bands found were associated to the colors of the fluids of each sample in the programming, to perform tests, having as main objective to verify the efficiency of the indication of the colors of the liquids.

III. RESULTS

Tracks that include the minimum and maximum values that the prototype sensors detected for the sample colors, dark and light are shown in the tables. Tables 2, 3 and 4 refer to the results of the readings of prototypes 1, 2 and 3, respectively.

It can be observed in Table 2 that prototype 1 was able to distinguish a range of values for each parameter, in addition there was a good spacing between the bands, which allowed to determine, in programming, the conditions that indicated the colors with a increase of three units in the case of maximum values and decrease of 3 units in the minimum values, to make a safer indication. It is observed that the greatest variation between the minimum and maximum values was only four units of bits.

TABLE. 2. BANDS OF VALUES RESULTING FROM THE READINGS OF PROTOTYPE 1.

Prototype 1			
Sample and Parameters	Results		Variation
	Mín.	Máx.	
Clear	674	678	4
Transparent	642	644	2
Red	538	539	1
Blue	432	434	2
Purple	201	202	1
Dark	24	28	4

Analyzing Table 3, it can be seen that the bands defined by prototype 2 were close to each other. In addition, the sample range containing the liquid in the purple color and the dark range had values in common. Therefore, he was not able to fully differentiate these two parameters. In the sample of purple color, which among the analyzed was the one that allowed to pass lower index of luminosity, and in the dark the sensor presented greater imprecision, when compared to the other results, the difference between the smaller and the greater result was of 26 units for the color purple and from 31 units to dark.

TABLE. 3. BANDS OF VALUES RESULTING FROM THE READINGS OF PROTOTYPE 2.

Prototype 2			
Samples and Parameters	Results		Variation
	Mín.	Máx.	
Clear	257	261	4
Transparent	250	256	6
Red	243	248	5
Blue	234	242	8
Purple	198	224	26
Dark	168	199	31

The results of prototype 3, presented in Table 4, show that the sensor defined different values for each color and that the bands had a good distance from each other. As the sensor is able to perform readings for the red, green and blue filter, these three parameters could be compared at the time of determining the color, which generates greater safety in the determination of the parameter being checked.

TABLE. 4. BANDS OF VALUES RESULTING FROM THE READINGS OF PROTOTYPE 3.

Sample and Parameters	Prototype 3					
	Red Filter		Green Filter		Blue Filter	
	Mín.	Máx.	Mín.	Máx.	Mín.	Máx.
Clear	106	114	293	307	893	945
Transparent	133	140	348	355	1100	1116
Red	241	251	671	680	2125	2141
Blue	450	463	710	718	2952	2984
Purple	2072	2087	1355	1368	10480	10504
Dark	6917	7483	2587	2597	5674	8765

TABLE. 5. BANDS OF VALUES RESULTING FROM THE READINGS OF PROTOTYPE 3.

Sample and Parameters	Prototype 3		
	Red Filter	Green Filter	Blue Filter
	Variation	Variation	Variation
Clear	8	14	52
Transparent	7	7	16
Red	10	9	16
Blue	13	8	32
Purple	15	13	24
Dark	566	10	3091

The Prototype 2 indicated erroneous colors when the sample was not completely positioned, but this impediment can be corrected at software level and prototype 3 in some results, did not present an answer to the color of the liquid being checked, since the result of the readings pointed to a different range from that shown in the data acquisition and, consequently, was related to that color in the programming.

In the analyzed requirements (greater distance of the ranges of values, precision and success in the indication of the color) prototype 1 stood out to the other two, in addition, the sensor of this prototype was the only one that did not show lack of precision in the absence of light.

IV. CONCLUSION

Among the three prototypes analyzed, two of them presented satisfactory results for this application. As prototype 3 did not present a color pattern, for this application, its use is not useful.

The prototype 1 presented better performance in all categories analyzed. Prototype 2 is also effective as long as it is checked only when the sample is fully positioned at its place of support, or if that error is corrected through programming. However, if the dark parameter, and not only the colors of the samples, are also relevant, its use will not be favorable because of the imprecision presented for this criterion. Another negative point is that because of the proximity of the ranges of values, it is more likely to present errors.

ACKNOWLEDGEMENT

The authors thanks SENAI Amazonas for laboratories infrastructure and components acquisition.

REFERENCES

[1] USGS. “The water in you”. 2018. Disponível em: <https://water.usgs.gov/edu/propertyyou. html>. Acesso em 06 de novembro de 2018.

[2] SINGH, AK. AGRAWAL, P. SINGH, AK. SINDH, O. “O Differentials of abnormal urine color: a review”. Annals of Applied Bio-Aciences. 2014.

[3] BOUDA, J.; QUIROZ-ROCHA, G. GONZÁLEZ, F. H. D. “Importância da coleta e análise de líquido ruminal e urina”. 2000. In: Gonzáles, F. H. D.; Borges, J. B.; Cecim, M. (Eds.). “Uso de provas de campo e de laboratório clínico em doenças metabólicas e ruminais dos bovinos”. Porto Alegre, Brasil, Gráfica da universidade Federal do Rio Grande do Sul.

[4] HADAD, S.; FRANÇA, E.; UCHÔA, E. “Mortes infantis por causas evitáveis e qualidade dos serviços de saúde: um estudo da percepção materna da doença e do atendimento à criança doente”. 2002.

[5] RAVEL, R. Laboratório Clínico: Aplicações Clínicas dos dados laboratóriais. 6. ed. Editora guanabara, 1997. 640 p.

[6] Ibrahim, S. N.; HAKIM, M, S. L.; ASNAWI, A. L.; & MALIK, N. A. “Automated Water Tank Filtration System Using LDR Sensor”. International Conference on Computer and Communication Engineering (ICCCE). 2016.

[7] SHEPHERD, R. L.; YERAZUNIS, W. S.; LAU, K. T.; & DIAMOND, D. (2006). “Low-Cost Surface-Mount LED Gas Sensor”. IEEE Sensors Journal, 6(4), 861-866.

[8] TAOS. “Datasheet: TCS230 Programmable Color Light-to-frequency converter”. (2013). Disponível em: <http://www.w-r-e.de/robotik/data/opt/tcs230.pdf>. Acesso em: 10 de julho de 2019.

[9] ARDUINO MAIS. “Detalhes sobre o Arduino UNO”. Disponível em: <http://arduinomais.blogspot.com/2014/06/detalhes-sobre-o-arduino-uno.html>. Acesso em: 25 de setembro de 2018.