Design a monitoring system for COVID-19 patients

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ABSTRACT

This paper considers to developing application software that can assist COVID-19 patients in-home quarantine to know their situations and call the emergence center when the patient needs it. It includes a smart band as well as an application on the smartphone, the smart band can determine blood oxygen levels, the temperature of the patient, environmental temperature and humidity, also daily activities that affect the decision to go to the hospital or stay at home. The core of the proposed project is using ontology and semantics web to process the data that coming from sensors (physiology and environment), and the information of patients stored in the database on the mobile application. The response depends on the dataset of affect sensors parameters and type of activity the patient at the time. There are three types of response to proposed program is (normal, alert, and emergency).

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1. INTRODUCTION

In this time, the COVID-19 epidemic has become a real challenge to the whole world, it is infected millions of people around the world within a short period of time. Therefore, it was greatly affected to some of the health sectors due to the number of patients whom the hospitals could not accommodate. Hence, the World Health Organization stressed the necessity of home quarantine.

Our proposed project is to assist COVID-19 patients in-home quarantine to know their situations. This proposed project includes two parts, smart band and an application on the mobile. The smart band must content main sensors (oximeter, temperature, and humidity). Therefore, transfer this data of COVID-19 patients to mobile application.

There are many projects that discuss making smart bands that can use to monitoring for the COVID-19 patients. The An.Dy project that is EU funded, it developed a smart band prototype capable of detecting temperature and make an alert when the temperature exceeds 37.5 °C. According to a news release by An.Dy project coordinator Italian Institute of Technology, the device can also monitor the distance between people [1]. The GOQii company that developed a smart band featuring sensors for measuring body temperature, heart rate, blood pressure and sleep apart from step count, the device is called Vital 3.0 [2].

Yakubu and Wereko [3] presented monitoring system using an arduino microcontroller that include three sensors: pulse, temperature and respiration rate. There are many paper that focus on the health monitoring systems (HMS) that useful for develop the ontology of our project. Budiyanto *et al.* [4] presented a monitoring system that using body temperature and heart rate. Rathy *et al.* [5] presented monitoring system that using heartbeat rate, pulse, blood pressure (BP), temperature sensors, also activities of the patient. Mach *et al.* [6] is design monitoring system that using information such as heat, heart rate, blood oxygen, orientation, and sleep time, and that transfer to personal computer. Jun *et al.* [7] presented the main activities of daily living (ADL), and show how affect it the performances of health monitoring systems. Mshali *et al.* [8] presented monitoring system that recognizing activity daily living (ADL), it using threshold based method and neural network. Mshali *et al.* [9] presented study of context-aware computing in health monitoring system.

For development the ontology, we must used many tools, for example description logic formalisms (TBox and ABox) to analyze and define the vocabulary of cases domains [10], [11]. Also, needed to use the web semantic languages such as RDF, OWL, and SPARQL to define the ontology [12]-[16]. Therefore, can extract the knowledge from analyze and define the general concepts of COVID-19 patients. In the current work, exploit these concepts for developing the application program that assists the patients to know has situations in home quarantine.

2. THE PHYSIOLOGY AND ENVIRMENT PARAMETERS

In this section, discusses many papers that focus on the physiology and envirment parameters that affect on COVID-19 patients. It is very useful to define the dataset of our ontology. Hence, can make decision table that content the relationship between the parameters of sensors and human activity. For environment parameters, there are many papers the describe the effect of the meteorological parameters (temperature and humidity) on daily new cases and daily deaths of COVID-19. Wu *et al.* [17] find the increasing 1 °C of temperature that reduces a 3.08% daily new cases and a 1.19 daily new deaths, also the increasing 1% of humidity that reduce a 0.85% daily new cases and a 0.51% daily new deaths.

Wang *et al.* [18] discuss the increase of temperature and humidity reduce the transmission of COVID-19 reduces R-value by about 0.023 in China and 0.020 U.S, and humidity rise reduces R-value by 0.0078 in China and 0.0080 (in the U.S.). If assuming a 30 degree and 25 percent increase in temperature and relative humidity from winter to summer in the northern hemisphere, we expect the R values to decline about 0.89 (0.69 by temperature and 0.20 by humidity). Hence, these papers proved that temperature and humidity have both negative relations to COVID-19 patients, but there aren't really studies that focus on the effect of the environment parameter on COVID-19 patients. For physiology parameters, there are many papers that focus on the oxygen level of COVID-19 patients.

Shah *et al.* [19] presented the min oxygen level for COIVD-19 patients at 92% in-home quarantine. Also, the Minnesota Department of health discussed the normal oxygen levels are at least 95% and sleeping normal levels around 90%. The research discussed the body temperature of COVID-19 patients, the result of these studies concludes the rate 26.5% of patients have 36 °C $<$ BT $\leq$ 37 °C, the 44% of patients is BT $\leq$ 35.5 °C, and half of the deaths has BT $\leq$ 35.5. For activity daily life, how to affect the COVID-19 patients, there aren't real studies on this domain [20]-[23]. And there aren't real studies that token about the effect of the different types of activity daily living (ADL) on the oxygen level and temperatures. But, there are many studies that conclude that reletion between the activity and the oxygen level many deasises such as chronic obstructive pulmonary disease [24]. also, the relation of activity with body temperature [25]. From above, we can conclude that activity daily life (ADL) affects the measure of oxygen level and human temperatures. therefore, can make the table of decision situations that depends on the information above for our proposed project such as in the Table 1.

Table 1. The situation of the COVID-19 patients

Situation	Oximeter	Patient Temperature	Human activity	Environment Humidity	Environment Temperature
Normal[21]	>95	37			
Normal[24]	95	36		60	22
Normal[24]	90	37		60	35
Normal[24]	90	36		60	10
Normal[21]	90-95	38	Sleeping		
Normal	93-94	38	ADL		>40
Alert	85-90	37-38			
Alert[21]	90-92	38		50	>32
Emergency[21]	<80				
Emergency	80-85	>39			
Emergency		>40			
Emergency[22]		<35			

3. THE ARCHITECTURE PROPOSED SYSTEM

The architecture of our proposed project can be divided into many parts when the smartphone received the data from the smart band as shown in Figure 1. The data can be store as a dataset that includes the parameters of sensors, activity is dependent on the time and location. In this proposed project, the activity can be classified into three sample activities (sleeping, watching, and walking) that can be recognized by smartphone. The second processing is to compare the received dataset with the knowledge base in the ontology to identify the situation of the COVID-19 patient that is use the SPARQL query to extract the situation, then the smartphone can include three responses (normal, alarm, and emergence).

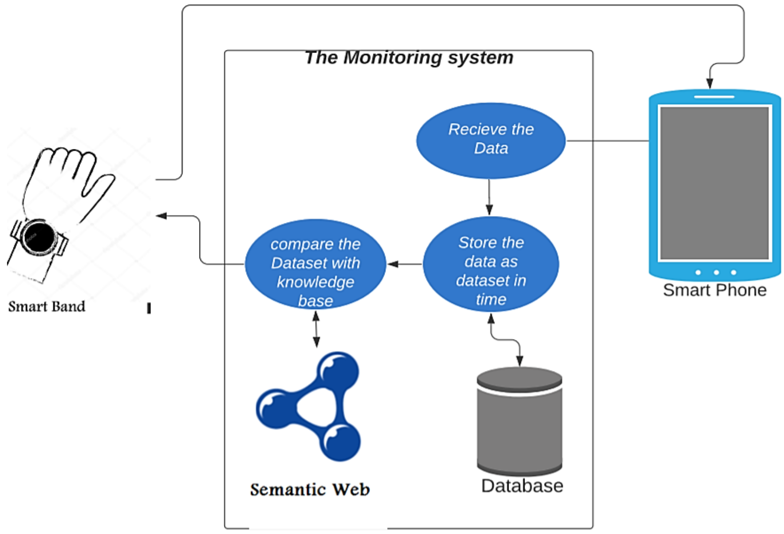

Figure 1. Architecture of the proposed system

4. THE ONTOLOGY

The main ontology defines capture the conceptual domain of Patient state and the parameters Sensors. It is included the concepts (or classes) and their relations (or roles). Then, can define axioms to the essence of the COVID-19 patient situation. Figure 2 shows the general concepts of the ontology. The top-level includes the classes such as physiology, environment, location, time, activity, and situation. The top level can be extended into subclasses such as temperature and humidity are a sub-class of environment. And, the activity concept can be divided into many subclasses (ADL, AMA, and IADL), each one has many sub-classes such as shown in Figure 3.

It is important to define the relationship between these concepts such as to define some roles such as the measure-physiology role connects the concept physiological and the patient concept. The measure-environment role connects the environment concept and the patient concept, the Make_Activity role connects between the activity concept and the patient concept. The has_situition role connects the patient concept and the situation concept.

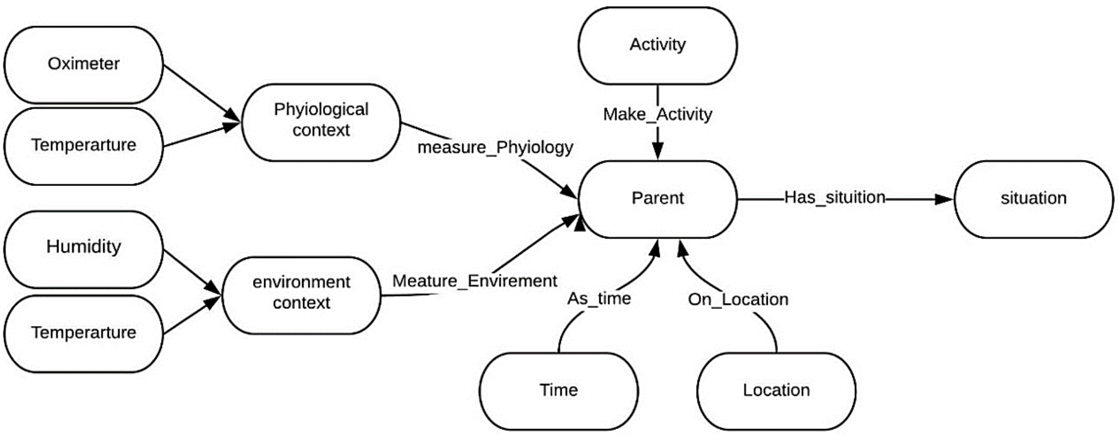

Figure 2. The top level of ontology

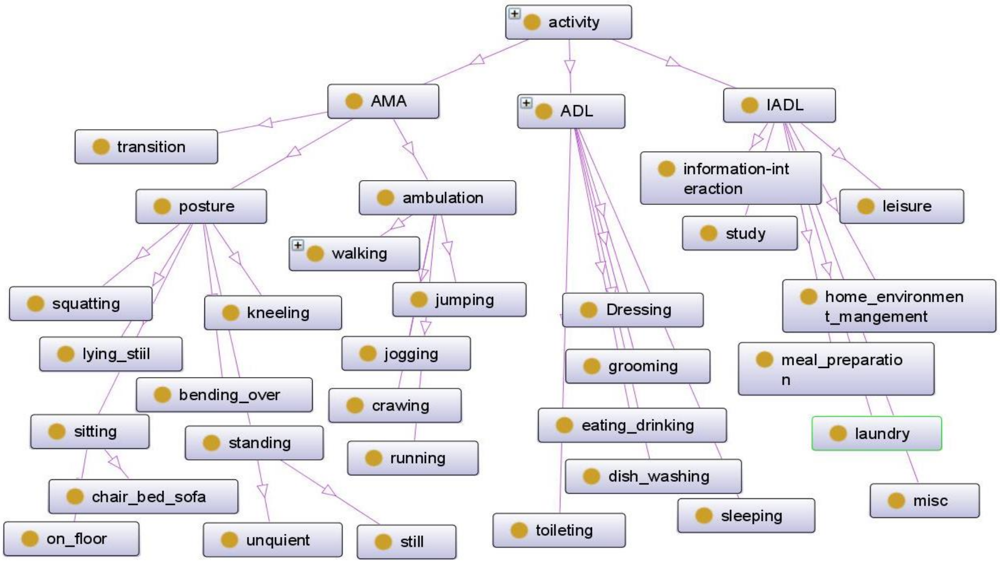

Figure 3. The concepts of activity

Therefore, define data proprieties of the concepts such as physiological context, it has two data properties measure-oxygen of oximeter concept and measure-temperature of temperature concept. Also, the environmental context has two data properties measure-humidity of humidity concept and measure-envir-temperature of temperature. Also, there are data properties at_time is date type for time concept.

Axiom 1: The patient class, there are exists a relationship (measure_phyiology) with phyiological context class, (measure_envionment) with environment context class, (make_activity) with activity class, (As_time) with time class, (on_location) with location class, and (Has_situation) with situation class, it can be shown as (1).

$$\begin{aligned}
&\text{Patient} \subseteq T \cap \exists \text{measure_phyisology.PhyiologicalContext} \\
&\cap \exists\ \text{measure_environment.EnvironmentContext} \\
&\cap \exists\ \text{make_activity.Activity} \\
&\cap \exists\ \text{As_time.Time} \\
&\cap \exists\ \text{on_location.Location} \\
&\cap \exists\ \text{has_situation.Situation} \qquad (1)
\end{aligned}$$

4.1. Identification of patient’s situation

The most important process is find the situation of patients in time, it can be identify depended on physiological and environmental sensors of the patient, which are define by the ontology by using the inter-linked concept paths (CP). In this context the process inherently use the SPARQL queries to compare the received data with definite role bases to identify the situation of patients such as show in Figure 4.

```
SELECT ?situation ?patient ?phytem ?phy ?act1
        WHERE { ?patient r:has_situation ?situation.
 ?phy r:measure_phyi_oxi ?patient;
 r:phyisology_oxy "z"^^xsd:integer.
 ?phytem r:measure_phyi_temp ?patient;
 r:Phyisology_Temp "y"^^xsd:integer.
 ?eni r:mesure_env_hui ?patient;
 r:measure_En_Hui "x"^^xsd:integer.
 ?envtemp r:musure_env_temp ?patient.
 ?act r:make_activity ?patient;
 rdf:type ?act1.
 ?act1 rdf:type owl:Class
 }
```

Figure 4. SPARQL query to identify the situation of patient

The system extract the data set by the inter-linking roles between concepts and eventually determines the situation of patient. The system would list all the dataset involving physiology, environment, location, time, and activity. For example: to identify the situation of COVID-19 patient that has blood oxygen level is 88, and body temperature is 36. Also, the environmental parameters are humidity is 40 and the type of activity is walking such shown in Figure 5. the response of the system is to give an alert to the patient to make medical procedures in this case such as taking medicine.

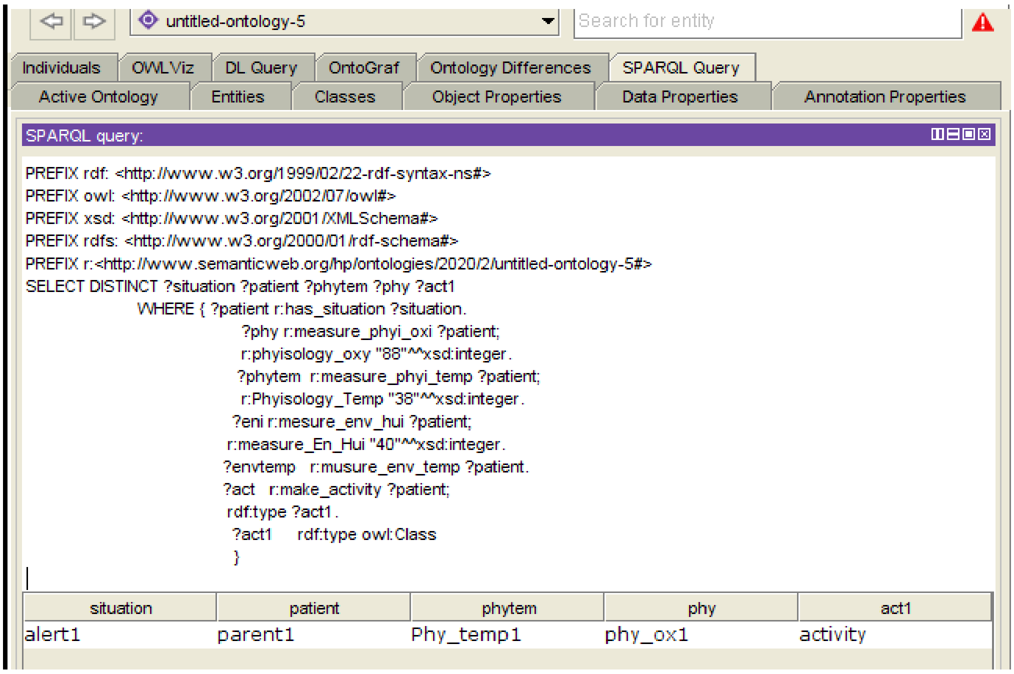

Figure 5. Example of identify the situation of patient

5. CONCLUSION

The core of the proposed project is to develop a system that assists the COVID-19 patient in-home quarantine. Hence, it reduces the number of patients that visit the health center. Also, it is useful for monitoring the patient during the time and tell him when the patient needs to visit the hospital. and can give medical advice when the situation input red zone such as take medicine to reduce the temperature. Also, it uses the parameters such as the oxygen level and body temperatures. It is the main parameter that reduces the number of deaths, can be recognized by the smart band. As well, there are many parameters such as the humidity and weather temperatures negatively affect the transmission and daily rate of cases COVID-19, but there isn't study of the effect these parameters and activities on COVID-19 patients.

REFERENCES

[1] S. K. Udgata and N. K. Suryadevara, "Advances in sensor technology and IoT framework to mitigate COVID-19 challenges," in *Springer Briefs in Applied Sciences and Technology*, pp. 55–82, 2021, doi: 10.1007/978-981-15-7654-6_4.

[2] S. Behera *et al.*, "Biosensors in diagnosing COVID-19 and recent development," *Sensors International*, vol. 1, p. 100054, 2020, doi: 10.1016/j.sintl.2020.100054.

[3] O. Yakubu and E. Wereko, "Internet of things based vital signs monitoring system: A prototype validity test," *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*, vol. 23, no. 2, pp. 962-972, 2021, doi: 10.11591/ijeecs.v23.i2.pp962-972.

[4] S. Budiyanto *et al.*, "Design and monitoring body temperature and heart rate in humans based on WSN using star topology," *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*, vol. 22, no. 1, pp. 326-334, 2021, doi: 10.11591/ijeecs.v22.i1.pp326-334.

[5] G. A. Rathy, P. Sivasankar, and T. Z. Fadhil, "An efficient IoT based biomedical health monitoring and diagnosing system using myRIO," *TELKOMNIKA (Telecommunication, Computing, Electronics and Control)*, vol. 18, no. 6, pp. 3050-3057, 2020, doi: 10.12928/TELKOMNIKA.v18i6.14375.

[6] V. Mach, M. Adamek, J. Sevcik, J. Valouch, and K. Barcova, "Design of an internet of things based real-time monitoring system for retired patients," *Bulletin of Electrical Engineering and Informatics (BEEI)*, vol. 10, no. 3, pp. 1648-1657, 2021, doi: 10.11591/eei.v10i3.2699.

[7] S. S. Jun *et al.*, "Development of fall detection and activity recognition using threshold based method and neural network," *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*, vol. 17, no. 3, pp. 1338-1347, 2019, doi: 10.11591/ijeecs.v17.i3.pp1338-1347.
[8] H. Mshali, T. Lemlouma, M. Moloney, and D. Magoni, "A survey on health monitoring systems for health smart homes," *International Journal of Industrial Ergonomics*, vol. 66, pp. 26-56, 2018, doi: 10.1016/j.ergon.2018.02.002.
[9] H. Mshali, T. Lemlouma, and D. Magoni, "A predictive approach for efficient e-health monitoring," *2015 17th International Conference on E-health Networking, Application & Services (HealthCom)*, 2015, pp. 268-273, doi: 10.1109/HealthCom.2015.7454510.
[10] S. Tongphu, B. Suntisrivaraporn, and P. Aimmanee, "Toward semantic similarity measure between concepts in an ontology," *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*, vol. 14, no. 3, pp. 1356-1372, 2019, doi: 10.11591/ijeecs.v14.i3.pp1356-1372.
[11] H. Hendi, A. Ahmad, M. Bouneffa, and C. Fonlupt, "Logisitics optimization using ontologies," *ICCSA 2014*, 2014.
[12] N. Ismail, E. G. Yassine, and S. Abdelalim, "Towards a semantic web of things framework," *IAES International Journal of Artificial Intelligence (IJ-AI)*, vol. 8, no. 4, pp. 443-450, 2019, doi: 10.11591/ijai.v8.i4.pp443-450.
[13] H. I. Hendi, A. Ahmad, M. Bouneffa, and C. Fonlupt, "Ontology based reasoning for solving passenger train optimization problem," *2016 Al-Sadeq International Conference on Multidisciplinary in IT and Communication Science and Applications (AIC-MITCSA)*, 2016, pp. 1-6, doi: 10.1109/AIC-MITCSA.2016.7759951.
[14] H. Hendi, A. Ahmad, M. Bouneffa, and C. Fonlupt, "A novel approach to define and solve the container terminals problems," *The Fourth International Conference on Computer Science, Computer Engineering, and Education Technologies (CSCEET2017)*, 2017.
[15] K. S. Aloufi, "Generating RDF resources from web open data portals," *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*, vol. 16, no. 3, pp. 1521-1529, 2019, doi: 10.11591/ijeecs.v16.i3.pp1521-1529.
[16] M. Hamiz, H. Haron, M. Bakri, and N. L. M. Lazim, "Ontology model for intake suggestion and preparation for Malay confinement dietary recipes," *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*, vol. 17, no. 1, pp. 481-488, 2019, doi: 10.11591/ijeecs.v17.i1.pp481-488.
[17] Y. Wu *et al.*, "Effects of temperature and humidity on the daily new cases and new deaths of COVID-19 in 166 countries," *Science of The Total Environment*, vol. 729, pp. 1-7, 2020, doi: 10.1016/j.scitotenv.2020.139051.
[18] J. Wang *et al.*, "Impact of temperature and relative humidity on the transmission of COVID-19: a modeling study in China and the United States," *BMJ Open*, 2020, doi: 10.2139/ssrn.3551767.
[19] S. Shah *et al.*, "Novel use of home pulse oximetry monitoring in COVID-19 patients discharged from the emergency department identifies need for hospitalization," *Academic Emergency Medicine*, vol. 27, no. 8, pp. 681-692, 2020, doi: 10.1111/acem.14053.
[20] A. M. Drewry, R. Hotchkiss, and E. Kulstad, "Response to 'body temperature correlates with mortality in COVID-19 patients'," *Critical Care*, vol. 24, no. 1, pp. 4-6, 2020, doi: 10.1186/s13054-020-03186-w.
[21] D. Kang and C. Ellgen, "The role of temperature in COVID-19 disease severity and transmission rates," *J. Med. Virol*, vol. 93, pp. 5358-5366, 2021, doi: 10.20944/preprints202005.0070.v1.
[22] M. H. Gul, Z. M. Htun, and A. Inayat, "Role of fever and ambient temperature in COVID-19," *Expert Review of Respiratory Medicine*, vol. 15, no. 2, pp. 171-173, 2021, doi: 10.1080/17476348.2020.1816172.
[23] M. No and H.-B. Kwak, "Effects of environmental temperature on physiological responses during submaximal and maximal exercises in soccer players," *Integrative Medicine Research*, vol. 5, no. 3, pp. 216-222, 2016, doi: 10.1016/j.imr.2016.06.002.
[24] N. S. Schenkel, L. Burdet, B. De Muralt, and J. W. Fitting, "Oxygen saturation during daily activities in chronic obstructive pulmonary disease," *European Respiratory Journal*, vol. 9, no. 12, pp. 2584-2589, 1996, doi: 10.1183/09031936.96.09122584.
[25] P. Webb, "Daily activity and body temperature," *European Journal of Applied Physiology and Occupational Physiology*, vol. 66, no. 2, p. 174-177, 1993, doi: 10.1007/bf01427059.

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