USE OF BARNES-HUT ALGORITHM TO ATTACK COVID-19 VIRUS

Radhouane Boughammoura

Department of Computer Science, Higher Institute of Computer Science of Mahdia, University of Monastir, Tunisia

ABSTRACT

The epidemy COVID-19 (khnown as Corona) is very dangerous. China, the epicenter of the epidemy, is the most infected country tell 07/04/2020 with 81 740 infected, and 3 331 death. To limit the exponential propagation of the virus we have to respect some consigns. Keep safe distance (1m or 3feet) is the most relevant consign in order to surround the spread of the epidemy. Our approach is used to detect possible contamination of persons. Barnes-Hut algorithm is based on quad, a data structure which detects certain proximity relative to persons and groups of persons. Alert is raised when the proximity between parsons is not respected. The algorithm can be used in decision making (e.g close frontiers). Experiments on real world dataset shows the efficiency of the algorithm.

KEYWORDS

COVID-19, person contamination detection, quad, query search, graphic design, artificial intelligence

1. INTRODUCTION

Statistics (www.Google.com) about Corona have demonstrated the danger of this virus all around the world relative to number of deaths and social economic consequences. It concern more and more of countries with high speed, and there is day after day more death.

There is currently no vaccine against corona disease, but you can decrease the risk of contamination of people if:

- You wash your hands frequently with a hydro alcoholic solution.
- You cover your nose and mouth with a tissue
- You avoid close contact (within 1 meter or 3 feet)
- In case of fever and difficulty in breathing consult a doctor

Using of mask is not sufficient every time. We have to use it only if:

- you are safe, using mask is mandatory only if we were in contact with infected person
- The mask is relevant only if it is associated with frequent hand washing with hydro alcoholic solution or soap and water

The contamination between people is with high probability when safe distance is not respected. When close contact is with infected person, this concerned person has to be put in quarantine for 14 days. If sign like cough or sneeze appears the person have to contact doctor without leaving home.

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Our paper will be organized as follows. Section 2 is related works. Section 3 is our approach where we present the algorithm Barnes-Hut. Section 4 is experimental results. Section 5 is conclusion.

2. Related Works

Related Works are all based on particles detection. There is two used data structures: Quad and Oct. Here we present three use cases.

Information Retrieval from deep Web [1, 2, 3, 4, 5, 5, 6, 7, 8, 9, 10, 11, 12, 14] is based on visual query interpretation of query interface. It is based on quad data structure (see .Mapping between galaxy entities and semantic entities in query interface make easy understanding visual interpretation of query interface.

In astronomy the challenge of simulating a many-body problem, for example movement of stars of one galaxy under gravitational force, is to use the Barnes-Hut (BH) algorithm [15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30]. Simulating BH space is partitioned in an hierarchic data structure. Space is partitioned in galaxies and stars and only particles, that are partitions close to each other interact.

TCAS (Traffic Collision Avoidance System) [31, 32, 33, 34, 35, 36, 37, 38, 39] is an alert system of traffic to avoid collision. Collision of many particles are very common. In aircraft collision alert detection, systems compute possible collusions between aircrafts in order to avoid them. Performance is utmost importance, since all calculations have to be done in real time.

3. A New Approach to Attack COVID-19 Virus

Close contact between persons is measured by GPS (Global Positioning System). If a patient has been in contact with person, covid-19 test should be done for this person for possible contamination with this virus.

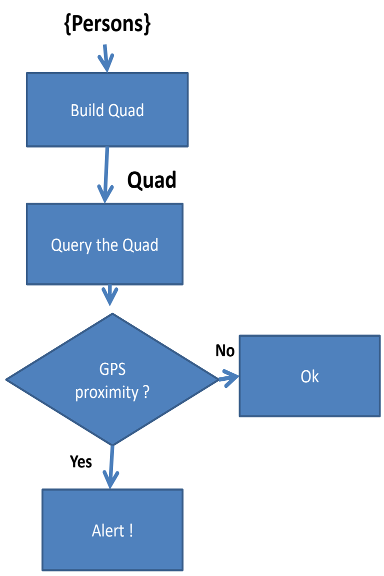

Figure 1. Functional schema of our approach

3.1. Graphical Representation and Group of Persons

What we need is a data structure to subdivide space, the answer in 2D is Quad, and answer in 3D is Oct. In our approach we will use quad. Quad begins with a square in the plane. This is the root of Quad. This large square can be broken into four smaller squares of half the perimeter and quarter the area each; these are the four children of the root. Each child can in turn be broken into 4 subsquares to get its children, and so on.

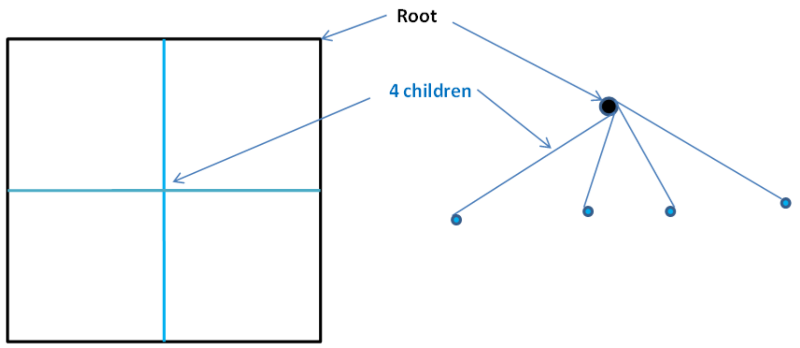

Figure 2 a quad and its corresponding representation

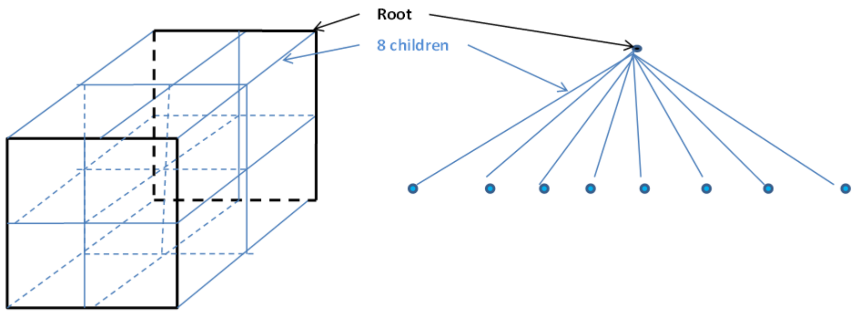

Figure 3. Oct and its corresponding graphical representation

3.2. Algorithm

The first procedure QuadtreeBuild, insert all particles in the Quad.

The second procedure QuadInsert(i, n) insert one particle i at node n in quadtree. By construction, each leave will contain either 1 or 0 particles. If subtree rooted at n contains more than one particle, determine which child c of node n particle i lies in and recurse QuadInsert(i,c). Move the particle already in n into the child. Let c be the child in which particle i lies recurse QuadInsert(i, c). If subtree rooted at n is empty, then n is a leaf, so store particle i in node n.

If the final sub square have cote sub-1 meter, we have to run an alert. However, when have cote more than 1 meter the algorithm cannot decide whereas there a risk of contamination or not.

Algorithm 1. Main procedure build the quad

I	public void **insert** (Key x, Key y, Value value) {
II	root = **insert**(root, x, y, value) ;
III	}

Algorithm 2. Procedure insert one person at the same time in the quad

1.	private Node **insert** (Node h, Key x, Key y, Value value) {
2.	If (h == null) return new Node (x, y, value);
3.	//// if (eq(x, h.x) && eq (y, h.y)) h.value = value; //duplicate
4.	else if (less(x, h.x) && less(y, h.y)) h.SW = **insert**(h.SW, x, y, value);
5.	else if (less(x, h.x) && ! less (y, h.y)) h.NW = **insert** (h.NW, x, y, value);
6.	Else if (! less (x, h.x) && less (y, h.y)) h.SE = **insert** (h.SE, x, y, value);
7.	Else if (! Less(x, h.x) && ! less (y, h.y)) h.NE = **insert**(h.NE, x, y, value) ;
8.	return h;
9.	}

Tableau 3. Procedure Query2D

```
procedure Query2D( Node h, Interval2D<Key> rect)
Begin
 if (h == null) return;
Key xmin = rect. intervalX.min();
Key ymin = rect.intervalY.min();
Key xmax = rect.intervalX.max();
Key ymax = rect.intervalY.max();
If ( rect.contains (h.x, h.y) )
    Print( " (    "+ h.x + ","+ h.y+")  "+ h.value);
If( less( xmin,h.x) && less(ymin,h.y) ) query2D( h.SW, rect);
If( less( xmin, h.x ) && ! less(ymax, h.y) ) query2D(h.NW, rect);
If( ! less( xmax, h.x) && less( ymin, h.y) ) query2D( h.SE, rect);
If( ! less ( xmax,h.x) && ! less(ymax, h.y) ) query2D ( h.NE, rect
);
End
```

The complexity of QuadtreeBuild depends on the distribution of the particles inside the bounding box. The cost of inserting a particle is proportional to the distance from the root to the leaf in which the particle resides (measured by the level of the leaf, with the root at level 0). If the particles are all clustered closely together the complexity can be large because the leaf can be far from the root.

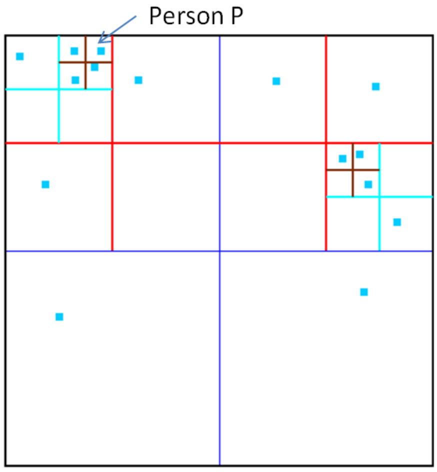

Figure 4. Building a Quad

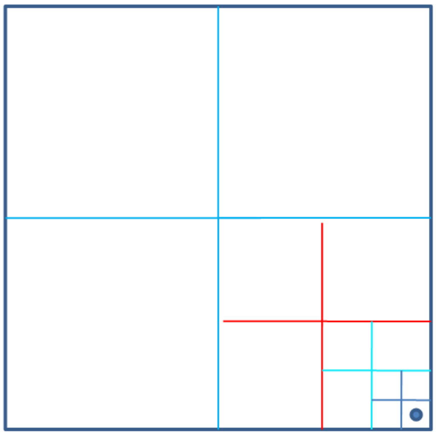

Figure 5. Complexity of the algorithm

If particles are uniformly distributed, so the leaves of the quad are all on the same level, the complexity of inserting one particles is log(n) (n is the number of partitions) and all the particles will be O(n*log(n)).

3.3. Illustrative Example

In figure 4 we show how done building a quad. We remark that every particle is hosted in one quadrant. Each quadrant has four sub-quadrant NW (North West), NE (North East), SW (South East), and SW (South West). For example, person P is queried NW, NW, NE, NE.

Figure 7 shows how proximity between persons can be detected efficiently using simple dynamic structure quad. Recursive partition of 2D space indicate where proximity between persons (and group) can occur. We suppose the persons (see blue points) are moving randomly around a scene. Using the algorithm there is no need to calculate proximity between each single particle relative to other particles. The algorithm detects the proximity just when two particles share the same node in particular predefined level in the tree. The more iteration, the more accurate the detection is.

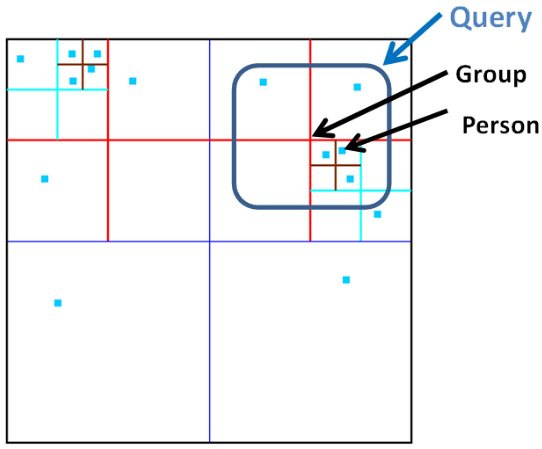

Figure 6. Searching certain proximity between persons

Once we build the Quad, we can, with the procedure Query2D, detect the number of persons and the number of group inside certain region set by user.

For example (see figure 6), the number of **found** (**person** or **group**) in the **Query** region is #found = {1Group, 1Group, 1Group, 5 person}.

4. EXPERIMENTAL RESULTS

Here how experimental measures are obtained:

- Persons: are moving
- Node: is a person or group of persons
- Query: is some region which search the persons in quad.

Let N be the number of persons and M the number of query.
N randomly generated persons and M number of randomly generated query. And then we count the number of found persons.

Table 4. Experimental results

Results		
#query	#persons	#FoundPersons
(0	,0)	0
(1	,1)	0
(2	,2)	0
(3	,3)	0
(4	,4)	0
(5	,5)	0
(6	,6)	0
(7	,7)	0
(8	,8)	0
(9	,9)	0
(10	,10)	2
(20	,20)	0
(30	,30)	1
(40	,40)	4
(50	,50)	19
(60	,60)	18
(70	,70)	22
(80	,80)	31
(90	,90)	50
(100	,100)	61
(200	,200)	229
(300	,300)	503
(400	,400)	905
(500	,500)	1292
(600	,600)	1898
(700	,700)	2733
(800	,800)	3252
(900	,900)	4117
(1000	,1000)	5050

We remark that as the number of queries increase as the number of found particles increase. In addition #Found particles increase remarkably when the number of query is more than 500 query.

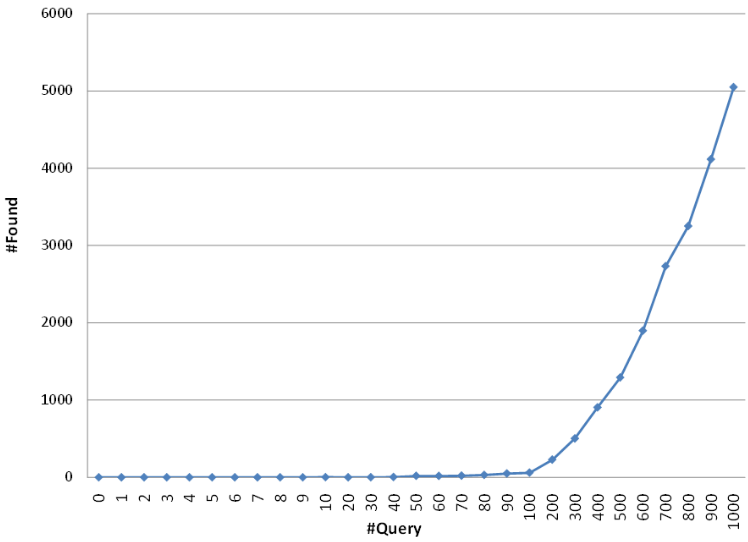

Figure 7. Experimental results

5. CONCLUSION

In this paper we have proposed a new approach which detects possible contamination of persons with Corona virus. We detect social distance between persons with O(n logn) complexity.

Every leaf node of a quad contains some special spatial information. Other pertinent properties can be measured (e.g age or #ChronicDisease) other than spatial information. Also we can extend the algorithm to detect contamination all around the word using Oct data structure.

REFERENCES

[1] Boughammoura, R., *Interrogation Non Supervisé de Services Web Cachés par Extraction Semantique de Requête et Interpretation Visuelle de Schéma*, phd thesis –FSEGS- University of Sfax, 2016.

[2] Boughammoura, R., M.N., Youssef, H., *A Fuzzy Wrapper of Web Pages*, TIGERA, 2007.

[3] Boughammoura, R., *Une Approche Floue d'Extraction d'Informations Pertinentes à Partir de Ressources Web par Apprentissage Inductif de Masques*, master thesis, 2007.

[4] Boughammoura, R., Omri, M.N., Youssef , H., *Fuzzy Approach for Pertinent Information Extraction from Web Resources*,The Journal of Computing and e-Systems, 2008.

[5] Boughammoura, R., Omri, M.N., Youssef , H., *Use of Conditional Random Field to Extract Pertinent Information Extraction from Web Resources*, TIGERA'2008 conf, The International Group of E-Research Systems and Applications, 2008.

[6] Boughammoura, R., Hlaoua, L., and MN. Omri, *VIQI: A New Approach for Visual Interpretation of Deep Web Query Interfaces*, in 8th International Conference on Computing Technology and Information Management (ICCM'2012), p. 344-349, 2012.

[7] Boughammoura, R., Hlaoua, L., Omri, M.N., *G-form: A Collaborative Design Approach to Regard Deep Form as Galaxy of Concepts*, in CDVE'2015, Maillorca, Spain.

[8] Boughammoura, R., Hlaoua, L., Omri, M.N., *G-Form:A New Approach for Visual Interpretation of Deep Web Form as Galaxy of Concepts*, The International Conference on Intelligent Systems and Applications, INTELLI'2015, 2015.

[9] Boughammoura, R., Omri, M.N., Hlaoua, L., *Information Retrieval from Deep Web Based On Visual Query Interpretation*. International Journal of Information Retrieval Research (IJIRR) 2012, 2 (4): p.45-59.

[10] Naouar, F., Hlaoua, L., Omri, M.N., *Information Retrieval Modeling Uncertain Confidence's Network*, IJIRR 7(2): 34-50, 2017.

[11] Garrouch, K., Omri, M.N., *Possibilistic Network based Information Retrieval Model*, ISDA2015:25-30, 2015.

[12] Elbahi, A., Omri, M.N., *Web User Interact Task Recognition Based On Conditional Random Fields* , CAIP (1) 2015, 740-751, 2015.

[13] Fkih, F., Omri, M.N., *IRAFCA: An O(n) Information Retrieval Algorithm based on Formal Concept Analysis*, Knowl. Inf. Syst. 48(2): 465-491, 2016.

[14] Chebil, W., Soualmia, L-F, Omri, M.N., Darmoni, *S-J: Indexing Biomedical Documents with a Possibilistic Network*, JASIST 67(4): 928-941, 2016.

[15] M.Fradi, Real-Time Application for Covid-19 Class Detection baseb CNN Architecture, Int' Conf' on Design and Test of Integrated Micro and Nano- Systems (DTS), 2021.

[16] H. Hassan, Z. Ren, H. Zhao, S. Huang, D. Li, S. Xiang, Y. Kang, S. Chen, B. Huang, Review and classification of AI-enabled COVID-19 CT imaging models based on computer vision tasks, Computers in Biology and Medicine, Volume 141, 2022.

[17] Gayathri J.L., Bejoy Abraham, Sujarani M.S., Madhu S. Nair, A computer-aided diagnosis system for the classification of COVID-19 and non-COVID-19 pneumonia on chest X-ray images by integrating CNN with sparse autoencoder and feed forward neural network, Computers in Biology and Medicine, Volume 141, 2022.

[18] Avinandan Banerjee, Rajdeep Bhattacharya, Vikrant Bhateja, Pawan Kumar Singh, Aime' Lay-Ekuakille, Ram Sarkar, COFE-Net: An ensemble strategy for Computer-Aided Detection for COVID-19, Jounal of Measurement, vol 187, 2022.

[19] Guoqing Bao and Huai Chen and Tongliang Liu and Guanzhong Gong and Yong Yin and Lisheng Wang and Xiuying Wang, COVID-MTL: Multitask learning with Shift3D and random-weighted loss for COVID-19 diagnosis and severity assessment, Journal of Pattern Recognition, 2022

[20] P. R. Negi, "Optimum utilization of COVID-19 Testing Kits using the Principles of Computer Science Binary Search Algorithm in Pooled Sample Testing," *2020 5th International Conference on Intelligent Informatics and Biomedical Sciences (ICIIBMS)*, 2020,

[21] S. Xie and P. D. Pedrow, "A Novel Active Needle Probe in an Atmospheric Pressure Corona-Based Cold Plasma Reactor With Admixtures of Helium and Dry Air," in *IEEE Transactions on Plasma Science*, vol. 48, no. 7, pp. 2418-2430, July 2020

[22] A. Nasir, K. Shaukat, I. A. Hameed, S. Luo, T. M. Alam and F. Iqbal, "A Bibliometric Analysis of Corona Pandemic in Social Sciences: A Review of Influential Aspects and Conceptual Structure," in *IEEE Access*, vol. 8, pp. 133377-133402, 2020

[23] T. Okada, Y. Baba, T. H. Tran and V. A. Rakov, "On Possible Influence of Corona Discharge on the Propagation Speed of Lightning Surges Along a Tall Grounded Object," in *IEEE Transactions on Electromagnetic Compatibility*, vol. 63, no. 1, pp. 172-180, Feb. 2021

[24] M. Borghei and M. Ghassemi, "A Deep Learning Approach for Discrimination of Single- and Multi-Source Corona Discharges," in *IEEE Transactions on Plasma Science*, vol. 49, no. 9, pp. 2936-2945, Sept. 2021

[25] T. Huiskamp *et al*., "Boosting the Energy Efficiency of a Nanosecond Pulsed Corona Plasma System With a Multiple-Wire Plasma Reactor," in *IEEE Transactions on Plasma Science*, vol. 48, no. 1, pp. 245-257, Jan. 2020

[26] M. K. Assudani and N. Sahu, "Review of Classifiers Used for Novel Corona Virus Foot-Print Detection," *2021 10th IEEE International Conference on Communication Systems and Network Technologies (CSNT)*, 2021

[27] M. S. S. Nia, P. Shamsi and M. Ferdowsi, "EMC Modeling and Conducted EMI Analysis for a Pulsed Power Generator System Including an AC–DC–DC Power Supply," in *IEEE Transactions on Plasma Science*, vol. 48, no. 12, pp. 4250-4261, Dec. 2020

[28] R. P. Fauzie Afidh and Z. A. Hasibuan, "Indonesia's News Topic Discussion about Covid-19 Outbreak using Latent Dirichlet Allocation," *2020 Fifth International Conference on Informatics and Computing (ICIC)*, pp. 1-6, 2020,

[29] B. Wang, Y. Zhao and C. L. P. Chen, "Hybrid Transfer Learning and Broad Learning System for Wearing Mask Detection in the COVID-19 Era," in IEEE Transactions on Instrumentation and Measurement, vol. 70, pp. 1-12, 2021,

[30] T. Zhang, M. Liu, T. Yuan and N. Al-Nabhan, "Emotion-Aware and Intelligent Internet of Medical Things Toward Emotion Recognition During COVID-19 Pandemic," in *IEEE Internet of Things Journal*, vol. 8, no. 21, pp. 16002-16013, 1 Nov.1, 2021

[31] M. K. Sharma, P. Kumar, A. Rasool, A. Dubey and V. K. Mahto, "Classification of Actual and Fake News in Pandemic," *2021 Fifth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC)*, pp. 1168-1174, 2021

[32] A. Andreas *et al*., "IoT cloud-based framework using of smart integration to control the spread of COVID-19," *ICC 2021 - IEEE International Conference on Communications*, pp. 1-5, 2021

[33] H. F. Al-Turkistani and H. Ali, "Enhancing Users' Wireless Network Cyber Security and Privacy Concerns during COVID-19," *2021 1st International Conference on Artificial Intelligence and Data Analytics (CAIDA)*, pp. 284-285, 2021

[34] L. Tawalbeh, F. Muheidat, M. Tawalbeh, M. Quwaider and G. Saldamli, "Predicting and Preventing Cyber Attacks During COVID-19 Time Using Data Analysis and Proposed Secure IoT layered Model," *2020 Fourth International Conference on Multimedia Computing, Networking and Applications (MCNA)*, pp. 113-118, 2020

[35] R. Sharma, N. Sharma and M. Mangla, "An Analysis and Investigation of InfoStealers Attacks during COVID'19: A Case Study," *2021 2nd International Conference on Secure Cyber Computing and Communications (ICSCCC)*, pp. 443-449, 2021

[36] H. Faria, S. Paiva and P. Pinto, "An Advertising Overflow Attack Against Android Exposure Notification System Impacting COVID-19 Contact Tracing Applications," in *IEEE Access*, vol. 9, pp. 103365-103375, 2021

[37] A. A. Shammari, R. R. Maiti and B. Hammer, "Organizational Security Policy and Management during Covid-19," *SoutheastCon 2021*, pp. 1-4, 2021

[38] J. Ahmed and Q. Tushar, "Covid-19 Pandemic: A New Era Of Cyber Security Threat And Holistic Approach To Overcome," *2020 IEEE Asia-Pacific Conference on Computer Science and Data Engineering (CSDE)*, pp. 1-5, 2020

[39] R. Srivastava, R. P. Mishra, V. Kumar, H. K. Shukla, N. Goyal and C. Singh, "Android Malware Detection Amid COVID-19," *2020 9th International Conference System Modeling and Advancement in Research Trends (SMART)*, pp. 74-78, 2020

AUTHOR

Radhouane BOUGHAMMOURA starts his high study as (SUP) student at Lycée Déodat de Severac, Toulouse, France. Next he received a bachelor of science and Master of Science from Faculté des Sciences de Monastir, University of Monastir, Tunisia. At February 2016 he is phd in Computer Science from Faculté des Sciences Economiques et de Gestion de Sfax, University of Sfax, Tunisia, under the supervision of Professor Mohamed Nazih Omri. From December 2008 to December 2022 he is assistant professor at University of Monastir.