THE RIGHT WAY TO AVOID CONTAMINATION BY COVID-19 VIRUS BASED ON BARNES-HUT ALGORITHM

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ABSTRACT

The spread of COVID-19 virus (known as Corona) has an exponential growth all around the world. China, the epicenter of the epidemic, is the most infected country. Tell 07/04/2020, she count 81 740 infected, 3331 death and dramatic socio-economic consequences. At start we have believed that stay at home is possible solution, but next we have thought that this is not the right way as new mutated virus appears. So, as there are no medicines, the best solution is to coexist with the virus. Our approach is in this direction. Keep safe distance (1m or 3 feet) is the most relevant consign in order to surround the spread of the epidemic. Our approach is used to detect possible proximity of persons and to protect them in advance before contamination. We propose an algorithm, Barnes-Hut algorithm, based on Quad, a data structure which detects some 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 show the efficiency of the algorithm.

KEYWORDS

artificial intelligence, COVID-19 virus, person contamination, contamination detection, Quad, graphic design,

1. INTRODUCTION

Statistics (www.Google.com) about COVID-19 virus 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.

The epidemic starts at China at 02/01/2020. As there is no vaccine against the virus, Chinese government has decided to coexist with it. They are using IA Robots. These devices serve to eliminate human-to-human contact in order to prevent the spread of the virus.

At 02/03/2020 the Tunisian government has announced the diagnosis of the first case of COVID-19 virus in Tunisia. This news has filled the Tunisian citizens in anxiety and worry.

Some hygiene and prevention measure was followed:

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

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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 degree 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.

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. Mapping between galaxy entities and semantic entities in query interface make easy to understand visual interpretation of query interface.

In astronomy also 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. Only particles, that are 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 is 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 AVOID COVID-19 VIRUS CONTAMINATION

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

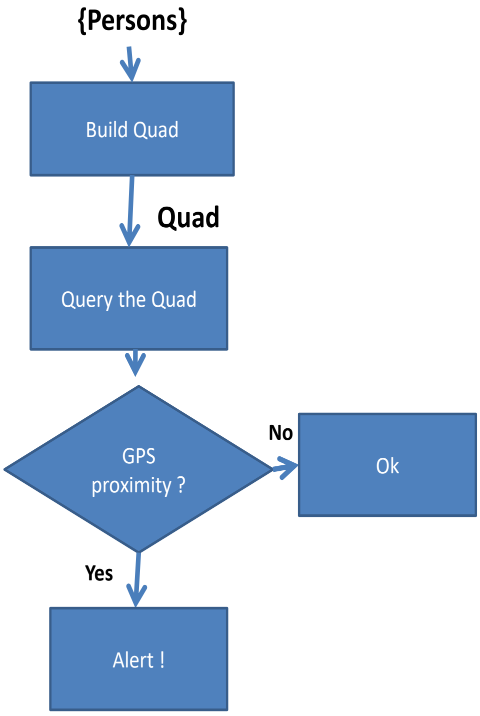

Figure 1. Functional schema of our approach

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.

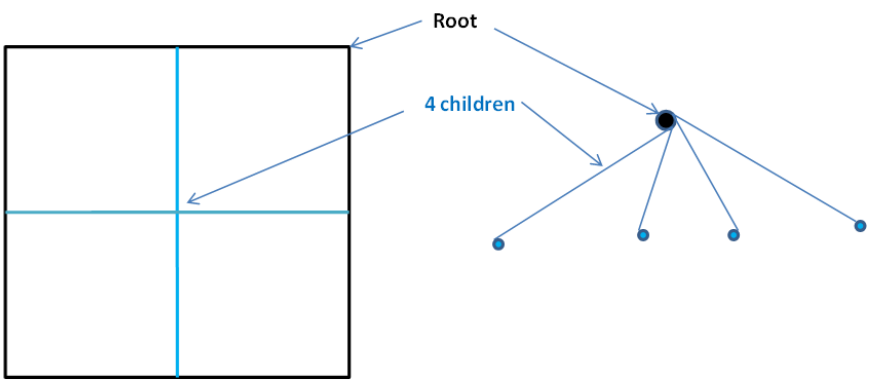

Figure 2. a quad and its corresponding representation

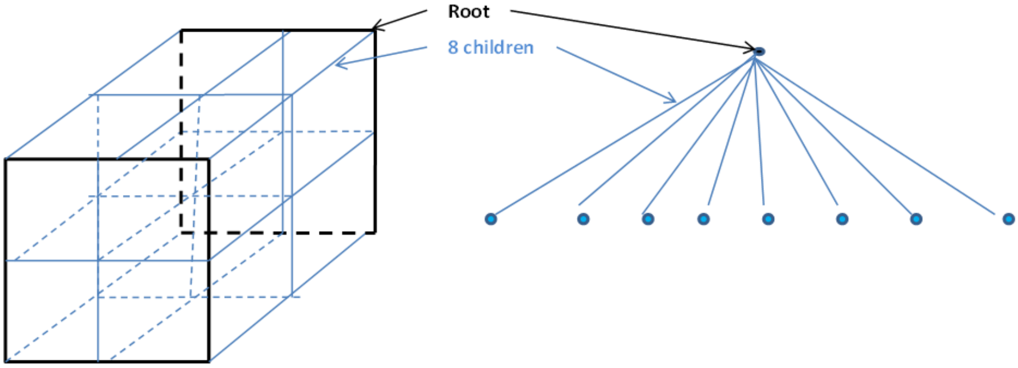

Figure 3. Oct and its corresponding graphical representation

3.2. Barnes-Hut Algorithm

The algorithm is based on the concept **Node**. It describes spatial uniform partition of persons. One person may be in one possible square: **NW** (North West), **NE** (North East), **SE** (South East), or **SW** (South West). First we have thought that rendering of persons in a Quad is a good idea, but as the number of persons may be very high we have thought another way which is calculation of number of nodes given number of particles.

```
class Node {
    Integer x, y;          // x- and y- coordinates
    Node NW, NE, SE, SW;   // four subtrees
    Value value;           // associated data: identifier of node
}
```

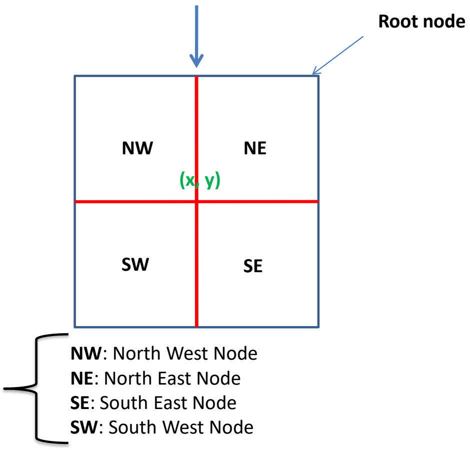

Figure 4. Analogy between concept Node and its visual presentation

The first procedure main, insert all persons, person by person, in the Quad.

The second procedure Quad Insert (i, n) insert one person i at node n. By construction, each leave will contain either 1 or 0 person. If subtree rooted at n contains more than one person, determine which child c of node n person i lies in and recurse QuadInsert (i,c). If subtree rooted at n is empty, then n is a leaf, so store person i in node n.

Agorithm 1. Main procedure build the quad

```
public void main() {
Quad quad = new Quad( );
for (int i = 0; i < N; i++) {
      Integer x = 100 * Math.random ( );
      Integer y = 100 * Math.random ();
     quad.insert (x, y,"P"+i);
}
```

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

```
public void insert ( Key x, Key y, Value value) {
root = insert( root, x, y, value ) ;
}
```

Algorihm 3: procedure which insert one person in the node

```
private Node insert (Node h, Key x, Key y, Value value) {
If ( h == null) return new Node ( x, y, value);
//// if ( eq( x, h.x) && eq (y, h.y ) ) h.value = value; //duplicate
else if ( less(x, h.x ) && less( y, h.y) ) h.SW = insert( h.SW, x, y, value);
else if ( less(x, h.x) && ! less ( y, h.y) ) h.NW = insert (h.NW, x, y, value);
Else if ( ! less (x, h.x) && less (y, h.y ) ) h.SE = insert ( h.SE, x, y, value);
Else if (! Less( x, h.x) && ! less (y, h.y ) ) h.NE = insert( h.NE, x, y, value) ;
return h;
}
```

Table 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
```

Query2D procedure makes it easy, without rendering the Quad to search persons in some proximity. For example the rectangle rect may be has, 1 meter x 1 meter, area and thus we can determine possible contamination of people in this region.

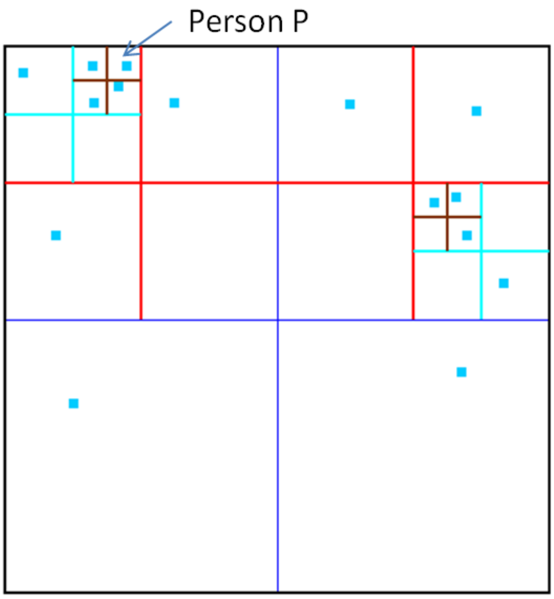

Figure 5. Building a Quad

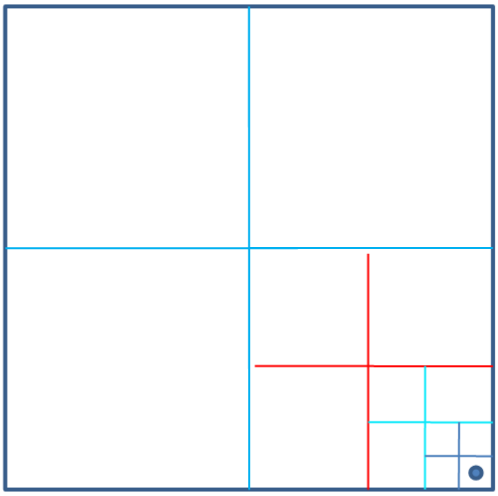

Figure 6. Complexity of the algorithm

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

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

We show (see figure 4) the way building a Quad. We remark that every person 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, and NE.

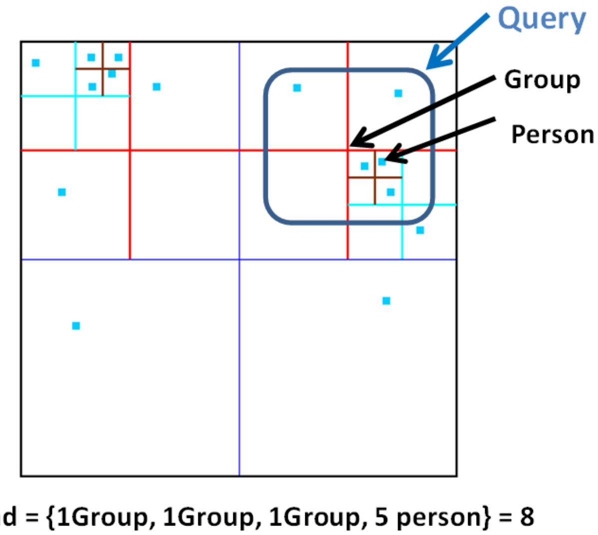

Figure 7. Searching certain proximity between persons

We remark (see Figure 7) shows the way proximity between persons can be detected efficiently using simple dynamic structure Quad. Recursive partition of 2D space indicates where proximity between persons (and/or 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 person relative to other persons. The algorithm detects the proximity just when two persons share the same node in particular predefined level in the tree. The more iteration, the more accurate the detection is.

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

For example (see figure 7), the number of **found** (**person** or **group**) in the **Query** region is #found = {1Group, 1Group, 1Group, 5 person}.

4. EXPERIMENTAL RESULTS

Here, the strategy used in our experimental measures:

- Persons: are moving. (x, y) coordinates are chosen randomly.
- Node (Group of Persons): cover a person or group of persons
- Query: is some rectangle region which searches 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 in some random region.

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
(2000	,2000)	21255
(3000	,3000)	47952
(4000	,4000)	84199
(5000	,5000)	128266
(6000,	6000)	191957
(7000,	7000)	259506
(8000,	8000)	353467
(9000,	9000)	423182
(10000,	10000)	521941

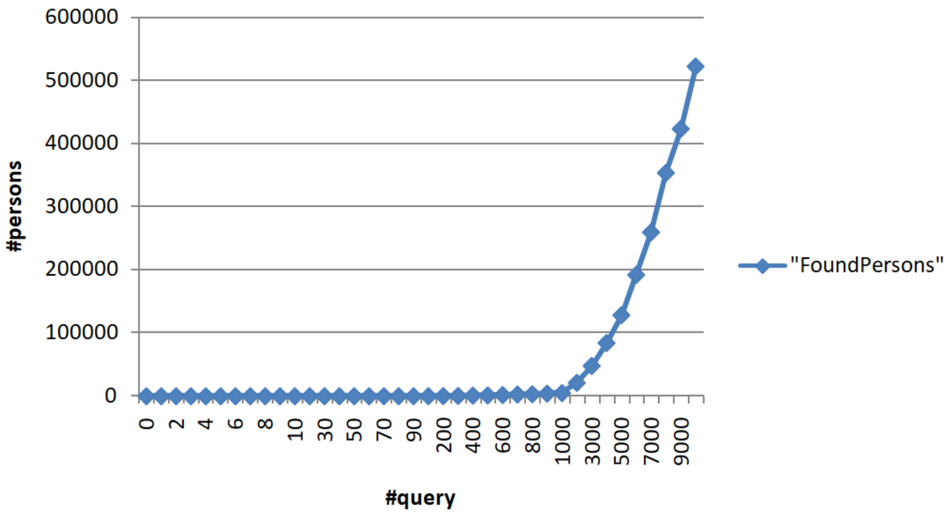

Figure 8. number of found persons for increasing number of query

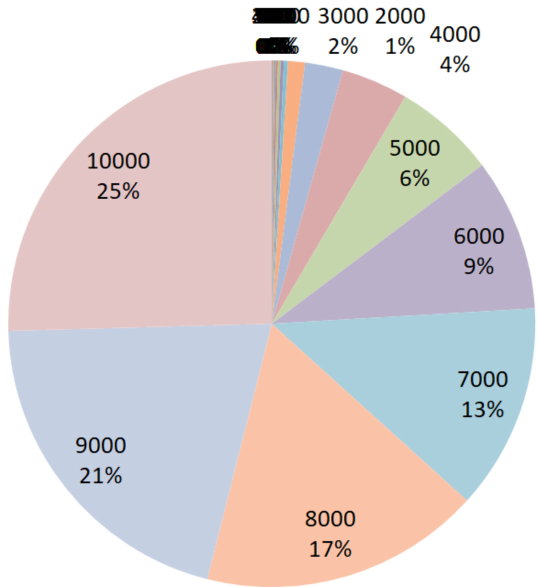

Figure 9. Percentage of contribution of every value (#persons) relative to the total sum

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

5. Conclusion

In this paper we have proposed a new approach which detects possible contamination of persons by COVID-19 virus. We detect safe distance between persons with O(n logn) complexity.

Every leaf node of a Quad contains some 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.

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