ISSN 2347 - 3983
Volume 8. No. 6, June 2020
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter50862020.pdf
https://doi.org/10.30534/ijeter/2020/50862020

# Greedy Algorithm based Health Care Resources Management System in the times of a Pandemic

**Rajibul Anam, Abdelouahab Abid**
App Research Division, Anam Research & Development Solutions, Dhaka, Bangladesh,
rajibulanam@bdanam.com
Faculty of Computer and Information Systems, Islamic University of Madinah, Madinah, Saudi Arabia,
abid@iu.edu

## ABSTRACT

Managing Health care resources is a very complicated task, especially in highly demanding periods such as natural disasters or disease outbreaks. Health care resources consisting of all facilities, materials, personnel are essential to provide adequate Health care services. These services have always been less than the ever-increasing demand, triggering the need for an effective and efficient health care resources management system. In this paper, five different algorithms are proposed, for hospital selection, doctors' and nurses' assignment, medicine and equipment distribution; hospital PPE management, and RedZone and Lockdown Area identification, which will support managing scarce health care resources and assist in the distribution decisions of limited assets.

**Key words :** Resource Management, Greedy Algorithm, Pandemic, Intelligent Distribution.

## 1. INTRODUCTION

One of the 30 articles of The Universal Declaration of Human Rights (UDHR) was the right of every human being to an adequate level of health and well-being. At the 21st century, this right can be made possible only through a robust healthcare system that effectively and efficiently manages health care resources, and in its core the workforce mainly doctors and nurses, bed capacity, medicines, and personal protective equipment.

In times of epidemic or pandemic, managing health care resources becomes more challenging and problematic. An example of that is the Corona virus disease (COVID-19) pandemic, which after six months from its identification, has infected more than 7 million with more than 400 thousand confirmed deaths in 216 countries and territories.

At present Novel Corona Virus (COVID-19) disease 2019 is spreading with the help of nature, which becoming unstoppable and has been declared a pandemic [1],[2]. The COVID-19 is named by the World Health Organization (WHO) which belongs to the Beta Corona Virus and is closely related to severe acute respiratory syndrome [3],[4]. COVID-19 is the most dangerous and aggressive obstacle in the world when it comes to the easiest way of infection and the high exponential growth of that disease [5].

COVID-19 has estimated that for the incubation period, it required 1 to 14 days, moreover the recent research says that it required 1 to 24 days for incubation period which has been declared by WHO and the US Centers for Disease Control (CDC) [3]. COVID-19 can attack easily to the weak respiratory system who has a history of diseases, at the poor immune system the COVID-19 can hide and wait to be aggressive in the future, at unhealthy environment if the patient smoke or suffer from inflammation in the lungs, then it gives COVID-19 to grow exponentially and attack the cells to spread the replication process [1],[5]. Scientists all over the world are working on COVID-19 to get the cure for it and vaccine or antidote has been invented so far but it will take 12 to 16 months to check the successful trial [5].

According to the WHO COVID-19 is transmitted by people through close contact and droplets [2]. There are some major prevention humans needs to do like keep the hands clean with hand wash or hand rub to maintain the hygiene, avoid touching eyes, mouth, and nose, coughing or sneezing into a bent elbow or tissue and then immediately disposing of the tissue, wearing a medical mask while going outside of the house and finally maintain social distance minimum 1 meter from individuals with respiratory [6-8].

COVID-19 is spreading exponentially, due to this reason Personal Protective Equipment (PPE) is a very important tool for human [6],[7]. PPE is not just a dress, according to the WHO and CDC gloves, medical masks, goggles, face shields, gowns, boots or closed work shoes are called parts of PPE [3],[7]. Among these parts gloves, medical masks, goggles, and gowns are mostly needed. Without these, hand wash and alcohol-based hand rub are used all the places in society [7]. There is also very demand for high-flow nasal oxygen machine which is called the ventilator [1],[3],[5-7]. Not all the COVID-19 patient needs ventilators but the critical patients required this machine. Doctor, Nurse, and medicine are the vital resource for any hospital, if any hospital face shortage of any resource from these three, then the hospital must face critical administrative failure [1].

According to the WHO, the pandemic is a disease or virus which spreads all over the country or the worldwide outbreak [7]. At pandemic general citizens faces lack of basic healthcare programs, facilities, skilled health workers, medicine [5]. To overcome these problems, need a pandemic management process, where most of the basic health care instruments, facilities, medicine, and skilled health workers will be available [9].

Resource management is a complicated system. Generally, resource management defined as executing a group of assets with its whole logistical support, security standards, and technical lifecycle [10],[11]. Most of the sectors admin use a computer-based asset management system but the system runs manually. There is no Engine or Artificial Intelligence (AI) to make the decision to distribute the resources.

Humans have two characteristics; one is selfishness, and another is altruistic. These dual characters always live with us and make us do ethical and un-ethical task [12]. There is three major critical theory which makes the resource management system unstable, firstly the political clientelism, which focuses on the political process and distributes the resource to the public, secondly the public choice theory of governance, which focus on the self-interest of the general citizens, lastly the core-periphery theory, which focuses on the unequal distribution of resources in the country based on the proximity to their core [12-14]. Most of the time political clientelism interrupts the resource management system by human influence. Most of the sophisticated systems like managing military, state, e-governance are run by AI [15]. The system takes the decision on what actions need to be taken. The results show that all the resource receivers would not receive according to their demand but they will get maximum possible supplies [16] moreover, the resource distribution methods run dynamically with a very short period of time in an automated resource management system [11]. For the COVID-19 resource distribution job become a stone breaking task, where political clientelism, the public choice theory of governance, and core-periphery theory does not work [6]. All over the world local government is losing the administrative control to manage and distribute the resource [17].To overcome the COVID-19 critical situation need to implement an automated decision-making system for resource management, where humans will not be interrupted by any external influence.

After analyzed these issues, proposed a solution, which is a fully automated decision-making system to distribute resources according to the demand at national crisis time. The proposed system uses the Greedy algorithm to take the decision, the main reason to choose the Greedy algorithm because it makes a sequence of choices, each choice is being the best choice at the available time moreover after taking the decision it never goes back to its earlier decision and it is straightforward and efficient. The greedy algorithm has three properties named benefit, weight, and profits [18],[19]. There are more than 100 types of greedy algorithms are available in the books [20], among those only a few of them are very popular named Knapsack, Dijkstra's Algorithm, Kruskal's Algorithm, Prim's Algorithm, Huffman Trees, etc. [21].

This paper presents different types of Greedy approach algorithms to manage the COVID-19 administrative decision-making resource management system. The main objective of this paper is to improve the administrative resource management task without any external and internal influence and identify the RedZone areas in the country. The rest of the paper is organized as follows, section 2, summarizes related research works. Section 3, details of the proposed system and algorithms. Section 4, discusses the results and finally, concluded the paper in section 5.

## 2. RELATED WORKS

COVID-19 was first detected in Wuhan, China in December 2019, WHO declared the outbreak of COVID-19 January 2020. WHO advised the preventive measures for the healthcare and public community like cleaning hands, avoid touching eyes, nose and mouth, wearing the medical mask, and keep the social distance. PPE standard also maintained by WHO and globally maintaining the supply chain of the PPE. WHO also comes up with a new concept of optimizing the availability of PPE, and open telemedicine and online portal for the public to avoid physical contact with the medical officers. Introduced a physical barrier with glass or plastic to reduce exposure with the patients. Restrict healthcare workers not to enter the patient's room if they are not involved with direct care. Provides proper PPE guideline how to use the medical mask, gown, gloves, goggles, apron, boots, moreover, they also categorized the PPE types for the different levels of medical staffs like health works, cleaners, visitors, lab technicians, car driver, and medical officers and administrative staff [7].

The developing countries, the main problem is, the country is rich but the peoples are poor. There is a noticeable difference between rural and urban poverty, incidence shows that opportunities and infrastructure differences among different sectors can be seen in rural and urban places. The research aimed to check the local government distributes and works better than the central government in rural communities and areas [13],[14]. Rural poverty is higher than urban poverty on behalf of roads, water, sanitation, education, medical, and electricity infrastructure. The allocation of resources should be channeled for the standard development of roads and social capital [13]. Most of the time due to central government influence, the distribution and the proper development got slowdown and developed places become more developed [14].

China is the country that first discovered the COVID-19 and they are the ones who face the first social attack in the world and at the same time, they have designed telemedicine to provide service to the infected patients. All countries are trying to understand the COVID-19 life cycle and it became the hardest part for the scientist because it changes its characteristics from time to time [1]. China government introduced a system named COVID-19 Docking Server [4]. This docking server predicts the binding modes between COVID-19 targets and the ligands including small molecules, peptide, and antibody. This server collects all types of information about the virus, from the data, the server constructs the structure of the virus life cycle and analyze the future of this virus. The docking server generates the virus's latest structure by gathering a regular collection of data from the COVID-19 positive patients [4]. Moreover, scientist come up with other solutions to predict COVID-19 by patients datasets using machine learning algorithms [22] and using real-time app to track the patients and generate alert [23].

The greedy algorithm is a very popular method for computer engineers, this algorithm makes a sequence of choices, each choice being in some way the best available at the time, moreover, decision-making time greedy algorithm never trackback for earlier decision [19]. The greedy algorithm is designed to get benefits, weights, and profits. From these objects, the algorithm takes the decision [20]. The greedy algorithm makes a sequence of choices, each step takes a decision at that time, the criterion to judge what is best for the greedy choice is called the local optimality criterion. The greedy algorithm is very popular because it is simply straightforward and efficient moreover, the greedy algorithm runs on four principles named Best-Global, Better-Global, Best-Local, and Better-Local [19]. Among all other tree traverse algorithms, the greedy algorithm is best and optimal for generic use [24]. The greedy algorithm also used in the Convolutional Neural Network and Graph Convolutional Networks to search various types of data [25].

## 3. PROPOSED SOLUTION

The proposed solution is an automated decision making COVID-19 resource management system. The system requires some basic input parameters from different levels according to figure 1 Top-level admin would key in the hospital name, town or area name, total population of the town or area, the distance of other hospitals. The second level of admin would enter the hospital's details in the town like the name of the hospital, number of doctors, number of nurses, number of patients can be accommodated, nearest hospital distance from this one, number of Intensive Care Unit (ICU), number of ventilators. The third level of admin(a) would insert the admitted patient's bed number in the hospital, number of active doctor and nurse numbers, admitted ICU patient numbers, and occupied ventilator number. The third level of admin(b) would input the regular positive tested COVID-19 patient's information details (which town and block the person lived) and date. The third level of admin(c) would key in the PPE Requirements, the number of gloves, medical masks, goggles, face shields, gowns, boots, hand rub, medicine, and ventilator. Forth level of admin(a) would request for Doctor or Nurse if they have a shortage due to quarantine. Forth level of admin(b) would request for medicine and equipment. Forth level of admin(c) would request for PPE. Government top official level admin would check the Red Zone and Lockdown areas. Figure 2 shows the Framework of the proposed system, where different types of admin key in the credentials and data would be stored in the system. Other types of admin requests for query and the system request the algorithms to take the decision and deliver the requested results

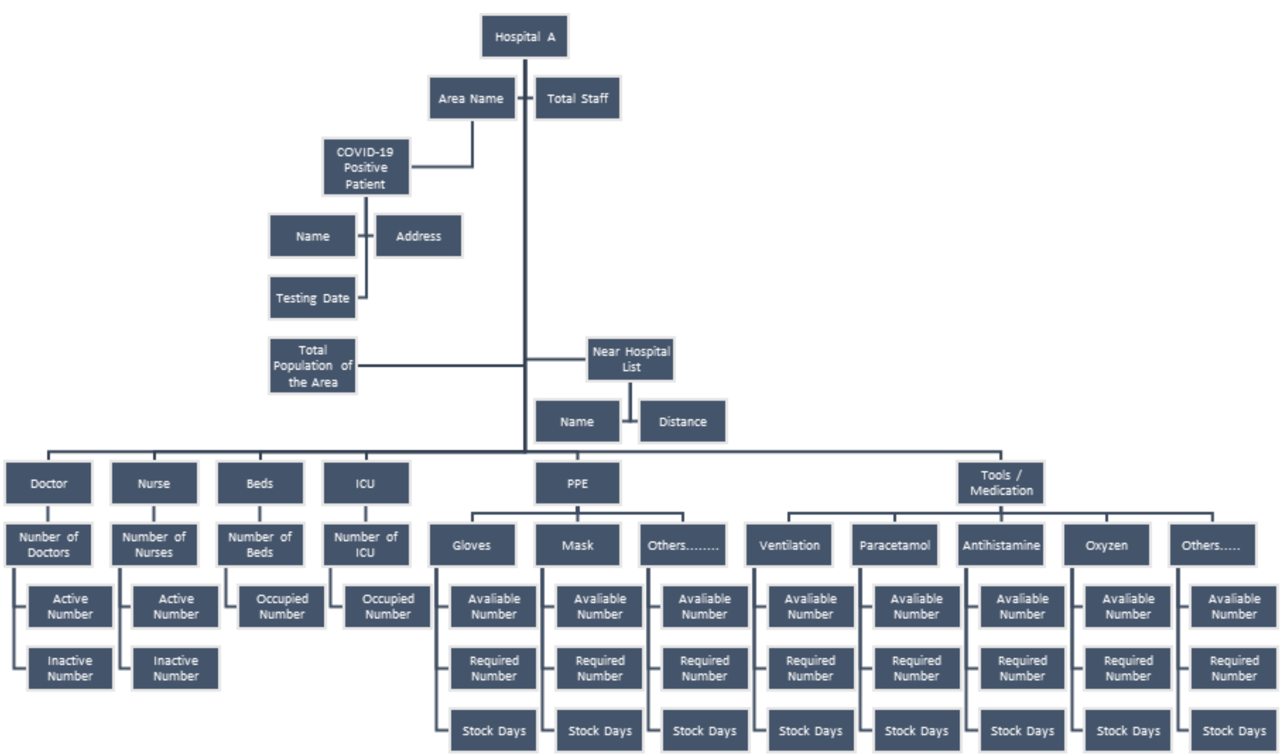



**Figure 1:** Taxonomy of a Hospital

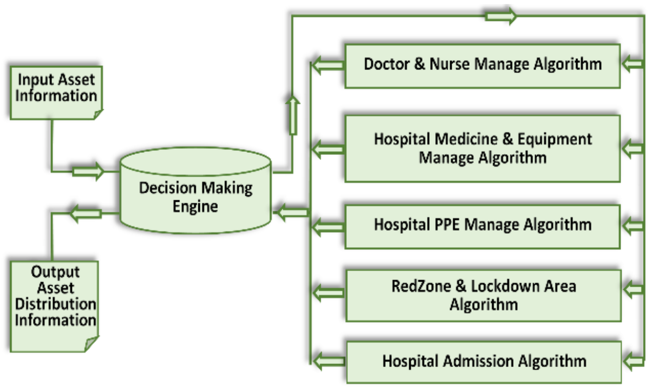



**Figure 2:** Framework of COVID-19 Resource Management System

### 3.1 Hospital Selection Process

On emergency, people call 911. The Emergency Ambulance received the patient and immediately transfer the patient to the nearest hospital. But most of the time Ambulance paramedic face problem after reached to the nearest hospital, all the beds and ICU is occupied by the patients, then they shift the patient to another hospital and visit every hospital until they find a bed to admit the patient to the hospital. Overwhelmed this time killing critical issues, used the Dijkstra's algorithm to select the nearest hospital [20],[21], where the patient can be admitted. Hospitals' information is stored in the system. Each hospital mapped as a node and each node is weighted directed graph because each hospital inserts the nearest hospital names and distance information from each other. The system combines all the hospitals' information to a single graph with the hospital's unique identification number provided by the government officials. So, when the ambulance paramedic searches for a bed in the hospital, system search all the nearest hospital in the town, then city, then other cities. Each edge carries the distance from each other, and each edge is connected to nodes. Each node contains the name of the hospital, the number of empty beds, and the ICU.

```
Input:
    G is a weighted directed graph;
Output:
    u is the selected node;
Variables:
    weight function w, source vertex s;
HospitalAdmission(G,w,s)
1.if (s.hospitalBed - s.hospitalPatientsBed)>0
2.      then
3.          returns;
4.  dist[s]←0;
5.  for all v ∈ V – {s}
6.      dodist[v]← ∞;
7.  S ← null;
8.  Q ← V;
9.  whileQ ≠ null
10. do u ← mindistance(Q,dist)
11.     if (u.hospitalBed - u.hospitalPatientsBed)> 0
12.         then
13.             break;
14.return u;
15.     S ← S ∪ {u};
16.     for all v ∈ neighbors[u]
17.         do ifdist[v] > dist[u] + w(u,v);
18.             thendist[v] ← dist[u] + w(u,v);
19. return dist;
```

**Figure 3:** Hospital Admission Algorithm

The Hospital Admission Algorithm starts when the paramedic searches for the hospital bed for new patient admission. Figure 3 illustrates the Hospital Admission Algorithm, where line 1 check the source node *s* hospital has available bed then exit the steps and select the hospital, if the hospital has no empty bed then start visiting other nodes following the Dijkstra's algorithm rules, line 11 checks the visited *low cost* nodes hospital bed is available then stop visit other nodes and select the *hospital*, if no bed is available then continue to visit other nodes until finding an *available bed for the patient*. The algorithm will select the nearest hospital available for the patient.

### 3.2 Doctor and Nurse Management Process

Doctor and Nurse is the core service provider to the hospital. Because of COVID-19 most of the hospital extends the doctor and nurse duties. After a long time over duty, some doctors and nurses become sick to do the regular duty moreover, some doctors and nurses get closer exposed with the COVID-19 patients without standard PPE they need to quarantine and some of them become COVID-19 positive. In both cases, hospitals face problem to manage routine doctors and nurses. Now most of the hospitals having a common problem to manage the shortage of doctors and nurses. For the central hospital authority, they failed to assign doctors and nurses according to the hospital demands because of political influence [12-14]. The proposed Doctor and Nurse Manage Algorithm will optimize the human effort of making the decision. Fractional greedy knapsack algorithm is used to distribute the new doctors and nurses to hospitals. This algorithm distributes the doctors and nurses according to the hospital's local area population, hospital total bed, total doctors, total inactive doctors, and total new doctors for the country. Suppose admin found all over the countries there are 2000 hospitals and only 300 hospitals have 1200 number doctors are inactive and admin has only 700 doctors are available to support these 300 hospitals, still 500 doctors are not in hand. So, the algorithm will distribute the 700 doctors among the 300 hospitals, maybe some hospitals will not get new doctors but most of the hospitals will get the doctors.

```
Input:
        S set of hospital list; N number of new doctors;
Output:
        New allocated doctor d;
Variables:
    benefit b; weight w; point p; new_doctor d;
DoctorAndNurseManage(S, N)
1.  for each item i in S
2.  bi← Si.TotalPopulation / Si.TotalBed;
3.    wi← Si.InactiveNumber ×Si.TotalDoctor;
4.    pi← bi × wi ;
5.          pTotal← + pi ;
6.  SortDecendingOrder(S);
7.  while d <= N
8.          di← Round((pi / pTotal) ×N) and di <= Si.InactiveNumber;
```

**Figure 4:** Doctor & Nurse Manage Algorithm

Figure 4 shows the doctor and nurse manage algorithm. Line 2 shows the benefit $b_i$ which carries the benefit of a hospital. The *benefit* is defined as a *hospital area total population* divided by *hospital total number of beds*. Line 3 shows the weight $w_i$, which carries the *weight* of a hospital. The *weight* is defined as *number of inactive doctors* multiply by *total doctors*. Line 4 illustrates the point $p_i$, *point* is defined here *benefit* divided by *weight*, line 8 shows the new doctor $d_i$, new doctor is a round number and is defined as point $p_i$ divided by total points $p_{Total}$ and multiply by *total number of new doctorsN*. The *d* carries the new allocated doctor for requested hospitals. When the system assigns new nurses, the same method would be applicable to distribute the nurses.

### 3.3 Hospital Medicine and Equipment Management Process

Every hospital has many doctors and they visit new patients every day. Every day each hospital provides medicine to the patients, among these medicines some are very vital and needed regularly. ICU and regular treatment purpose medical officers used many devices and some of them starts malfunction without any notice. Due to COVID-19, every hospital needs extra Ventilation machines in ICU. The central hospital authority face problem to serve the medicine and equipment all over the country according to the hospitals' demand. The proposed algorithm would dispense the medicine or equipment after analyzing the hospital, local people, number of COVID-19 infected patients, and hospital beds number. Suppose central hospital authority found all over the country there are 2000 hospitals and only 300 hospitals do not have enough oxygen cylinders, these 300 hospitals requests for 6000 pieces of oxygen cylinders, requests of the cylinders are not equal for every hospital, one hospital request for 60, another 10. The system would allocate the cylinders according to the needs, but some hospitals might not receive any cylinder because their surrounding data shows that they need it, but a little bit of delay would not make any big crisis.

Figure 5 Illustrates the Hospital Medicine and Equipment Manage Algorithm. Line 2 arranges the benefit $b_i$, the *benefit* defined by *total population of the town* divider by *total bed of the hospital*, line 3 shows the weight $w_i$ calculation procedure. Weight is defined by the *total positive COVID-19 patient number* multiply by *total occupied bed number*, line 4 illustrates the profit $p_i$, *profit* is defined as *benefit* multiply by *weight* and the *result* is divided by *item stock days*. Line 8 shows the distribution $d_i$ of the total new items to all the hospitals.

Input:
    *S* set of hospital list; *N* number of new item;
Output:
    New allocated Medicine item *d*;
Variables:
    benefit *b*; weight *w*; point *p*; new_item *d*;
**MedicineAndEquipmentManage(***S, N***)**
1. **for** each item *i* in *S*
2. $b_i \leftarrow S_i.TotalPopulation / S_i.TotalBed;$
3. $w_i \leftarrow S_i.TotalCOVID\text{-}19Patient \times S_i.OccupiedBed;$
4. $p_i \leftarrow (b_i \times w_i) / S_i.StockDays\ ;$
5. $p_{Total} \leftarrow + p_i\ ;$
6. **SortDecendingOrder(***S***)**;
7. **while** $d <= N$
8. $d_i \leftarrow$ **Round(**$(p_i / p_{Total}) \times N$**)** ***and*** $d_i <= S_i.RequiredNumber;$

**Figure 5:** Hospital Medicine & Equipment Manage Algorithm

### 3.4 Hospital PPE Management Process

Hospitals have many types of staff like healthcare workers, cleaners, lab technicians, medical officers, nurses, and drivers [7]. Due to COVID-19, all these staffs work daily shift basis and all of them need to get physical contact with the patients and all types of staff must use PPE while performing their job. Most of the PPE is one-time use only. So, there is a huge demand for PPE for every hospital staff. Suppose a hospital with 400 staff, every day the hospital required 450 to 600 pieces of PPE each item. The admin needs to distribute the PPE according to the demand from the hospitals. The proposed Hospital PPE Manage Algorithm would allot the PPE. Suppose central hospital authority found all over the country there are 2000 hospitals and only 600 hospitals do not have enough PPE, these 600 hospitals request for 70000 pieces of medical mask, request for the medical mask is not equal every hospital. But the distribution should be smooth, so all the hospitals received the medical mask.

Figure 6 illustrates the Hospital PPE Manage Algorithm, line 2 calculates the benefit $b_i$, the *benefit* is defined as the *total population of the town* is divided by *total bed of the hospital*. Line 3 shows the weight $w_i$ calculation, the *weight* defined *total staff of the hospital* multiply by *total occupied beds*, line 4 illustrates the profit $p_i$ calculation, *profit* is defined as *benefit* is divided by *weight* and the result is divided by *item stock days*.

Input:
    *S* set of hospital list; *N* number of new PPE item;
Output:
    New allocated PPE item *d*;
Variables:
    benefit *b*; weight *w*; point *p*; new_item *d*;
**PPEManage(***S, N***)**
1. **for** each item *i* in *S*
2. $b_i \leftarrow S_i.TotalPopulation / S_i.TotalBed;$
3. $w_i \leftarrow S_i.TotalStaff \times S_i.OccupiedBed;$
4. $p_i \leftarrow (b_i / w_i) / S_i.StockDays\ ;$
5. $p_{Total} \leftarrow + p_i\ ;$
6. **SortDecendingOrder(***S***)**;
7. **while** $d <= N$
8. $d_i \leftarrow$ **Round(**$(p_i / p_{Total}) \times N$**)** ***and*** $d_i <= S_i.RequiredNumber;$

**Figure 6:** Hospital PPE Manage Algorithm

### 3.5 RedZone and Lockdown Area Identification

There is no accurate system or criteria to declare Home lockdown or RedZone. But to control and stop spreading the virus need to declare lockdown and RedZone areas. As a human, it is very hard to declare lockdown or RedZone his native place or place where his relative stays, moreover due to political influence sometimes central hospital authority failed to do so [12-14], same time declare the Home lockdown and RedZone is an important task. To overcome the biased situation proposed the RedZone & Home lockdown Area Algorithm. The system will automatically decide by analyzing the present statistic data.

Figure 7 illustrates the RedZone & Lockdown Area Algorithm, line 2 computes the benefit $b_i$, *benefit* is defined as *total COVID-19 positive patient*, line 3 analyses the weight $w_i$, the weight is defined as *total population of the area*, line 4 computes the point, the point is defined as *benefit* is divided by *weight* and the series of the result is calculated by the *AreaCluster* method, the area cluster method processes the *area profits* and make a group of the areas. Line 7-8 checks if the area has any *benefit* then assign *Home lockdown* to a specific area, Line 9-10 checks the *total population of the COVID-19 positive* is more than 0.01% then assign *RedZone* to the specific area.

```
Input:
        S set of hospital list;
Output:
        New alert zone  d;
Variables:
    benefit b; weight w; point p; new_item d;
AlertManage(S)
1.  for each item i in S
2.    bi ← Si.TotalCOVID-19Patient;
3.    wi ← Si.TotalPopulation;
4.    pi ← AreaCluster(bi / wi);
5.  SortDecendingOrder(S);
6.  for each item i in S
7.        if bi > 0 then
8.            di ← HomeLockdown;
9.        if pi > 0.01% of Si.TotalPopulation then
10.           di ← RedZone;
```

**Figure 7:** RedZone & Lockdown Area Algorithm

## 4. DISCUSSION

The proposed system applied five different algorithms but all of them are greedy based. All the decisions have been made by the system according to the benefits, profits, and points. The main objective of the discussion is how the benefits, profits, and points are calculated according to the local value of the hospital data to make the decisions.

### 4.1 Hospital Admission Algorithm

The Hospital Admission Algorithm selects the nearest hospital from the ambulance which has an empty bed for patients to admit. Figure 3 already discussed details about the algorithm. Figure 8, shows the weighted directed graph as a sample, where *s* (nearest hospital for the patient) is the source node of the graph; *a, b, c, d, e, f, g* and *h* (other listed nearest hospital) are the other nodes of the graph. In the graph, *s* is the first hospital, *a, b* and *c* are the nearest hospital from *s*.

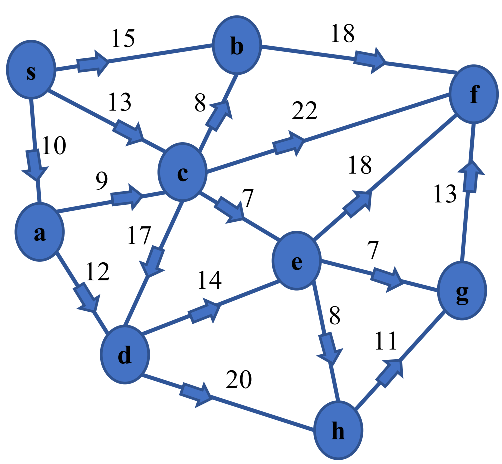



**Figure 8:** Weighted Directed Graph

Table 1 Shows the Directed Graph details information in the table, where Hospital is the node of a graph, Distance retains the directed graph edge value and Empty Bed preserves the available bed information.

**Table 1:** Weighted Directed Graph Details

| Hospital | Visited | Distance | Founded By | Empty Bed |
|---|---|---|---|---|
| **s** | Yes | 0 | | 0 |
| **a** | Yes | 10 | **s** | 0 |
| **c** | Yes | 13 | **s** | 0 |
| **b** | Yes | 15 | **s** | 0 |
| **e** | Yes | 20 | **c** | 5 |
| **d** | Yes | 22 | **a** | 0 |
| **g** | Yes | 27 | **e** | 6 |
| **h** | Yes | 28 | **d** | 11 |
| **f** | Yes | 33 | **b** | 3 |

Figure 9 shows the graphical illustration of the Weighted Directed Graph Shortest Path, the algorithm selects the *e* hospital because has the shortest path edge value 20 and has an empty bed for admission value 5, same time *f* hospital has the longest path *edge* value is 33 and has 3 empty bed for admission. Other shortest path *edges* do not have any empty beds. The complexity of this algorithm is $O(v^2)$.

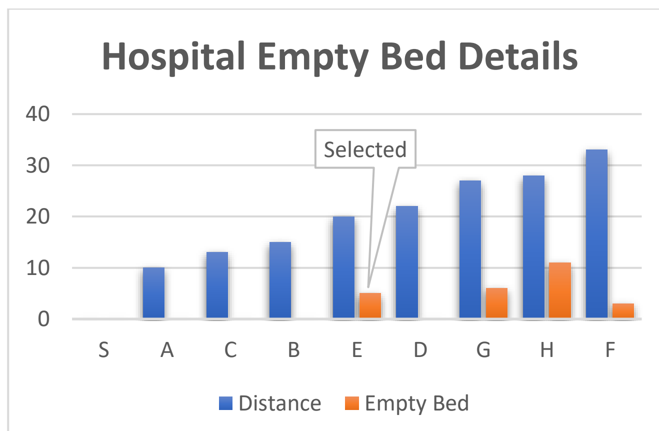
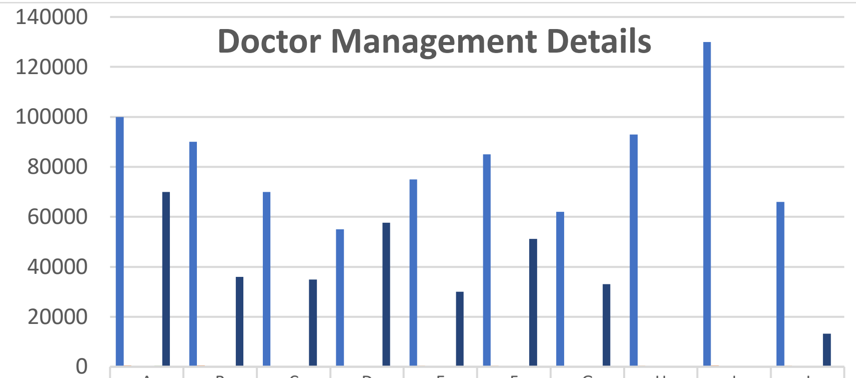



**Figure 9:** Weighted Directed Graph Shortest Path

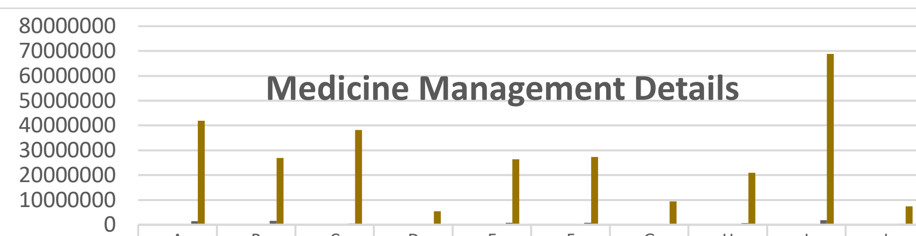
### 4.2 Doctor and Nurse Manage Algorithm

The Doctor and Nurse Manage Algorithm (figure 4) allot the doctors and nurses all the hospitals in the country. For distribution, purposes used the fractional knapsack algorithm. Figure 10 shows *s* are listed 10 hospitals. Assume each hospital has limited beds, doctors, and nurses. Among these hospitals, they have a shortage of 42 doctors, and these hospitals requested 42 numbers of new doctors. The central hospital authority managed to provide only 13 new doctors. The algorithm first computes the Benefit, which is the Total Population divided by Total Bed, the Benefit is a fraction of local and hospital population. Weight is planned Total Doctor multiply by Inactive Doctor, the Weight is a product of doctors. Points are counted as the multiplication of Benefit and Weights. The hospital *A* has inactive (requested) 7 doctors and the algorithm provides 3 doctors, also the hospital *J* has requested for 2 doctors and the algorithmprovides 1 doctor, the algorithm distributes the 13 new doctors according to their local population and hospital doctor's population. The algorithm distributes the doctors in a balanced manner so most of the hospital (requested) would receive doctors. The time complexity of this algorithm is $\theta(n \log n)$.




| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| Total Population | 100000 | 90000 | 70000 | 55000 | 75000 | 85000 | 62000 | 93000 | 130000 | 66000 |
| Total Bed | 500 | 600 | 300 | 300 | 450 | 400 | 300 | 400 | 500 | 400 |
| Benefit | 200 | 150 | 233 | 183 | 167 | 213 | 207 | 233 | 260 | 165 |
| Total Doctor | 50 | 60 | 30 | 35 | 45 | 40 | 32 | 40 | 55 | 40 |
| Inactive Doctor | 7 | 4 | 5 | 9 | 4 | 6 | 5 | 0 | 0 | 2 |
| Weight | 350 | 240 | 150 | 315 | 180 | 240 | 160 | 0 | 0 | 80 |
| Points | 70000 | 36000 | 34950 | 57645 | 30060 | 51120 | 33120 | 0 | 0 | 13200 |
| New Doctor | 3 | 2 | 1 | 2 | 1 | 2 | 1 | 0 | 0 | 1 |

**Figure 10:** Doctor and Nurse Distribution Process




| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| Total Population | 100000 | 90000 | 70000 | 55000 | 75000 | 85000 | 62000 | 93000 | 130000 | 66000 |
| Total Bed | 500 | 600 | 300 | 300 | 450 | 400 | 300 | 400 | 500 | 400 |
| COVID-19 Positive Patient | 3000 | 2700 | 1700 | 900 | 1800 | 2100 | 1100 | 1900 | 3800 | 900 |
| Occupied Bed Number | 489 | 599 | 289 | 267 | 438 | 367 | 288 | 378 | 488 | 400 |
| Stock Days | 7 | 9 | 3 | 8 | 5 | 6 | 7 | 8 | 7 | 8 |
| Medicine Request | 1400 | 1400 | 1300 | 1000 | 1800 | 1000 | 1900 | 1700 | 3300 | 1600 |
| Benefit | 200 | 150 | 233 | 183 | 167 | 213 | 207 | 233 | 260 | 165 |
| Weight | 1467000 | 1617300 | 491300 | 240300 | 788400 | 770700 | 316800 | 718200 | 1854400 | 360000 |
| Points | 41914286 | 26955000 | 38157633 | 5496863 | 26332560 | 27359850 | 9368229 | 20917575 | 68877714 | 7425000 |
| Allocated Medicine | 1383 | 889 | 1259 | 181 | 869 | 903 | 309 | 690 | 2272 | 245 |

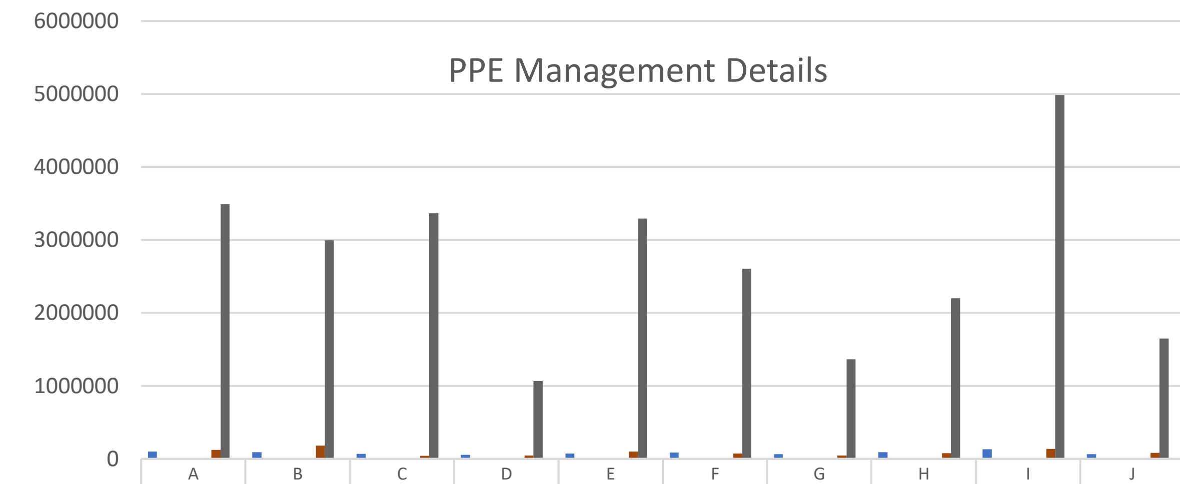
**Figure 11:** Hospital Medicine and Equipment Distribution Process

### 4.3 Hospital Medicine & Equipment Manage Algorithm

The Hospital Medicine and Equipment Manage Algorithm (figure 5) distribute medicine and equipment all demanded hospitals in the country. This algorithm also based on fractional knapsack algorithm. Figure 11 Shows *A, B .... J* are listed 10 hospitals. Suppose each hospital has limited beds, doctors, and nurses. All the hospitals requested 16400 pcs of Antihistamine tablets. It is very hard to distribute 9000 pcs tablets manually among the requested hospital in a well-adjusted way, but the algorithm distributes 9000 pcs tablets in a sensible manner. The algorithm first calculates the Benefit which is Total Population divided by Total Bed, the Benefit is a fraction of local and hospitalpopulation. Weight is calculated as the number of COVID-19 Positive Patients multiply by Occupied Bed Number, which is a product of patient and bed. Points are counted Benefit multiply by Weights which is the product of hospital beds and patients and divided by Medicine Stock Days which is a quotient of medicine and hospital beds. Hospital *A* requested 1400 pcs tablets, the algorithm provides 1383 pcs of tablets, hospital *D* requested for 1000 pcs tablets and algorithm provides 181 pcs and the same method distributes to other hospitals. The time complexity of this algorithm is $\theta(n \log n)$.

### 4.4 Hospital PPE Manage Algorithm

The Hospital PPE Manage Algorithm (figure 6) sensibly distributes the PPE. The PPE is very important for the medical staff self-protection. Figure 12 Shows *A, B .... J* are listed 10 hospitals. Assume each hospital has limited beds, doctors, and nurses. All the hospitals requested 16270 pcs of medical masks and the central hospital authority managed to provide 12000 pcs of medical masks. The proposed fractional knapsack algorithm distributes the face masks conferring to the local data. The algorithm first calculates the Benefit which is the Total Population divided by Total Bed, the Benefit is a fraction of local and hospital population. Weight is designed as number of total staff multiply by Occupied Bed Number, weight is a product of patient and hospital occupied bed numbers. Points are calculated Benefit multiply by Weight which is a product of hospital bed and population, and divided by Stock Days which is a quotient of the hospital population and stock days. The hospital *A* requested for 1750 pcs of medical masks and they received 1551 pcs of medical masks, hospital *D* demanded for 1225 pcs and the algorithm provides 475 pcs, and other hospitals also received medical masks same ways. The time complexity of this algorithm is $\theta$(n log n).

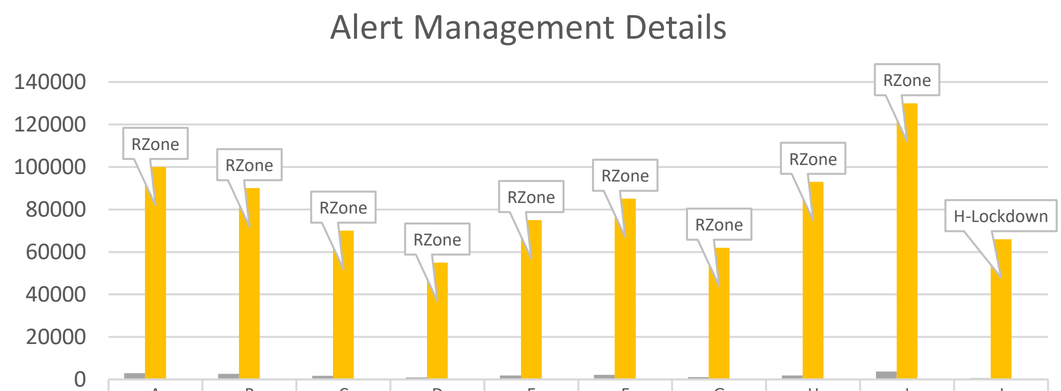



| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| Total Population | 100000 | 90000 | 70000 | 55000 | 75000 | 85000 | 62000 | 93000 | 130000 | 66000 |
| Total Bed | 500 | 600 | 300 | 300 | 450 | 400 | 300 | 400 | 500 | 400 |
| Total Staff | 250 | 300 | 150 | 175 | 225 | 200 | 160 | 200 | 275 | 200 |
| Occupied Bed Number | 489 | 599 | 289 | 267 | 438 | 367 | 288 | 378 | 488 | 400 |
| Stock Days | 7 | 9 | 3 | 8 | 5 | 6 | 7 | 8 | 7 | 8 |
| PPE Request | 1750 | 2100 | 1800 | 1225 | 1575 | 1400 | 1120 | 1400 | 2500 | 1400 |
| Benefit | 200 | 150 | 233 | 183 | 167 | 213 | 207 | 233 | 260 | 165 |
| Weight | 122250 | 179700 | 43350 | 46725 | 98550 | 73400 | 46080 | 75600 | 134200 | 80000 |
| Points | 3492857 | 2995000 | 3366850 | 1068834 | 3291570 | 2605700 | 1362651 | 2201850 | 4984571 | 1650000 |
| Allocated PPE | 1551 | 1330 | 1495 | 475 | 1462 | 1157 | 605 | 978 | 2214 | 733 |

**Figure 12:** Hospital PPE Distribution Process

### 4.5 RedZone & Lockdown Area Algorithm

The RedZone & Lockdown Area Algorithm (figure 7) identifies the places, where need to be declared RedZone and Home lockdown. When the virus starts spreading, it becomes very significant to stop humans from socialization. Figure 13 Shows *A, B .... J* are listed 10 areas. Assume each area has COVID-19 positive patients. The proposed algorithm first processes the Benefit which is the COVID-19 Positive Patient number of an area, Weight is the Total Population of the area, the Points is calculated as Benefit is divided by Weight which is the quotient of the patient and total population. The algorithm checked when the Points is more than 0.01% then declared RedZone and less than 0.01% then declared as Home lockdown for the patient and family members. The area J all the patients and family members declared to be a Home lockdown, and area *A* to *I* all the areas need to be declared RedZone. The time complexity of this algorithm is $\theta(n \log n)$.




| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| Benefit | 3000 | 2700 | 1700 | 900 | 1800 | 2100 | 1100 | 1900 | 3800 | 600 |
| Weight | 100000 | 90000 | 70000 | 55000 | 75000 | 85000 | 62000 | 93000 | 130000 | 66000 |
| Points | 0.030 | 0.030 | 0.024 | 0.016 | 0.024 | 0.025 | 0.018 | 0.020 | 0.029 | 0.009 |

**Figure 13.** RedZone & Lockdown Area Process

## 5. CONCLUSION

Novel COVID-19 is a deadly virus that is spreading in many ways. All the medical scientists over the world are working day and night to develop a cure for COVID-19; moreover, the cure will take more than a year from now to get fully functional. Every hospital is receiving lots of patients every day. Some hospitals failed to give support due to overhead patients. Government facing problems providing doctors, nurses, medicine, equipment, PPE, and many other supporting things. To overcome this critical problem, some Greedy algorithms are proposed, which will automatically distribute the resources to the requested place with a suitable quantity. The Greedy algorithm analyzes the requested parameters and distributes the resources. The Greedy algorithm may not be the optimal solution for resource distribution, but in the chronic period, the best possible solution is needed. The five proposed algorithms provide five different types of output to the distribution process. The future plan is to implement the greedy algorithm for factory product production purposes. Hoping the five algorithms will help the Hospitals to manage the resources properly at this COVID-19 crisis.

## REFERENCES


1. Andrea Remuzzi and Giuseppe Remuzzi, **COVID-19 and Italy: what next?**, The Lancet, v. 395, p. 2215-2218, 2020. https://doi.org/10.1016/S0140-6736(20)30627-9
2. Khae Hawn Kim, **COVID-19**, International Neurourology Journal, Editorial, vol. 24, no. 1, 2020.
3. Carlos del Rio, MD Preeti N. Malani and MD MSJ, **COVID-19—New Insights on a Rapidly Changing Epidemic**, JAMA, vol. 323, no. 14, 2020. https://doi.org/10.1001/jama.2020.3072
4. Ren Kong, Guangbo Yang, Rui Xue, Ming Liu, Feng Wang, Jianping Hu, Xiaoqiang Guo and Shan Chang, **COVID-19 Docking Server: An interactive server for docking small molecules, peptides and antibodies against potential targets of COVID-19**, Biomolecules, Cornell University, p. 1-16, 2020.
5. Rimon Adel Louis, **COVID 19 Cure Technique**, Social Science, Humanities and Sustainability Research, vol. 1, no. 1, 2020.
6. T. M. Cook, **Personal protective equipment during the COVID-19 pandemic – a narrative review**, Anaesthesia Editorial, April, 2020. https://doi.org/10.1111/anae.15158
7. **Rational use of personal protective equipment for coronavirus disease (COVID-19)**, WHO, February, 2020.
8. W S Lim, **Pandemic flu: clinical management of patients with an influenza-like illness during an influenza pandemic**, THORAX, vol. 62, 2007.
9. LunHua Li and Pradeep Ra, **Applications of E-Health for Pandemic Management**, The 12th IEEE International Conference on e-Health Networking, Applications and Services, 2010.
10. Joachim Schneider, Armin Gaul, Claus Neumann, Jürgen Hogräfer, Wolfram Wellßow, Michael Schwan and Armin Schnettler,**Asset Management Techniques**, 15th Power Systems Computation Conference, se. 41, p.1-11, 2005.
11. Safwan Ali Al Salaimeh, **Mathematical description of resources distribution for logistics information systems**, Leonardo Journal of Sciences, no. 32, p. 1-9, 2018.
12. Blair Fix,**An evolutionary theory of resource distribution**, real-world economics review, no.90, 2019.
13. Edem Ebong, Charles D. Ekpenyong and E. E. Eteng, **Resource Distributionand Economic Advancement of Rural Communities in Nigeria**, International Journal of Advanced Research in Public Policy, Social Development and Enterprise Studies, vol. 2, no. 1, 2017.
14. Andrew K. Ledford and Scott M. Lynch, **Comparing Theories of Resource Distribution: The Case of Iran**,

Socius: Sociological Research for a Dynamic World, vol. 5, p. 1-15, 2019.

15. Zinaid Kapić, Fatka Kulenović, **Optimization of Resource Distribution by Using Linear Programming in Python Programming Language**, 12th International Scientific Conference on Production Engineering,2019.
16. Irina Zaitseva, Oleg Malafeyev, Afanasy Zubov, Lidiya Bondarenko and Vyacheslav Orlov, **Statistical game-theoretic model of the optimal labor resources distribution**, Journal of Physics: Conference Series, vol. 1399, no. 3, 2019. https://doi.org/10.1088/1742-6596/1399/3/033054
17. **Rational use of personal protective equipment for coronavirus disease (COVID-19) and considerations during severe shortages**, WHO, April, 2020.
18. Jeff Erickson, **Algorithms**, Book, Chapter 4, 1st edition, June 2019.
19. S.A. Curtis, **The Classification of Greedy Algorithms**, Science of Computer Programming, vol. 49, no. 1–3, p. 125-157, 2003.
20. Witold Bednorz, **Advances in Greedy Algorithms**, Book, 1st edition, November 2008.
21. Brandon Skerritt,**Algorithmic Design Paradigms**, Book, 1st edition, November 2019.
22. Kolla Bhanu Prakash, S. Sagar Imambi, Mohammed Ismail, T Pavan Kumar, YVR Naga Pawan, **Analysis, Prediction and Evaluation of COVID-19 Datasets using Machine Learning Algorithms**,International Journal of Emerging Trends in Engineering Research, vol. 8, no. 5, 2020. https://doi.org/10.30534/ijeter/2020/117852020
23. Chinecherem Umezuruike, Wilson Nwankwo, Prisca Tibenderana, John Patrick Assimwe, Muhirwa Ronald, **International Journal of Emerging Trends in Engineering Research**, International Journal of Emerging Trends in Engineering Research, vol. 8, no. 5, 2020. https://doi.org/10.30534/ijeter/2020/41852020
24. Pongsaphol Pongsawakul, **Faster Greedy Consensus Trees**, Data Structures and Algorithms, Cornell University, March, 2020.
25. Guohao Li, Guocheng Qian, Itzel C. Delgadillo, Matthias Müller, Ali Thabet, Bernard Ghanem, **SGAS: Sequential Greedy Architecture Search**, Machine Learning, Cornell University, April, 2020.