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Optimization Method to Find the Priority Group to be Vaccinated Against Corona Virus

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Abstract: Current evidence shows that the corona virus spreads mainly between people who are in close contact with each other. More than 3.9 million people died globally due to covid-19. There are various types of vaccine produced against this virus. But the vaccine produced so far is insufficient to vaccinate the whole society. Production of vaccine is in its maximum capacity. Now it is better to give vaccine in a priority order. Here an optimization model is given using Dynamic programming to find the set of people in a region to be vaccinated first.

Keywords: Frequent Item Sets, State Variable, Covid-19, Dynamic Programming.

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1. Introduction

Covid-19 is an infectious disease caused by newly discovered corona virus. Covid-19 affect different people in different ways. More than 3.9 million people died due to covid-19 globally. This is a serious issue. By continuous mutation, the virus may sweep away millions of lives in this universe. Current evidence shows that the virus spreads mainly between people who are in close contact with each other, typically with in 1 meter. It is very necessary to stop spreading of the diseases. The scientists discovered different vaccines against this virus. The production of vaccine is in full swing, but the vaccine produced is insufficient while considering its global need. But we cannot wait till the production is sufficient to meet the global need for vaccine. Here a parallel system must be chosen. That is production of vaccine should be in its maximum capacity, at the same time vaccination is given to people in a priority basis. The priority for vaccination must be decided wisely so as to control the spreading of the virus.

In this paper an optimization model is developed to find those people who have more contact with the society. If such people are affected by the virus then there is greater chance of spreading. If they are given priority to taking vaccine, it will be of great help to arrest the speed of the virus spreading. The set of people who have more contact with the society is likely a frequent item set in Data mining.

2. Related Works

As an important data mining problem, frequent pattern mining plays an essential role in many data mining tasks, such as mining associations [2, 8], sequential patterns [13, 18] maximum patterns and frequent closed patterns [5, 12, 16] classification

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[6, 15] and clustering [4]. There have been many algorithms developed for fast mining of frequent patterns which can be classified into two categories. The first category, candidate generation and test approach, such as Apriori [2] as well as many subsequent studies, are directly based as an anti-monotone. If a pattern with K items is not frequent, any of its super-patterns with $(K+1)$ or more items can never be frequent. A candidate generation and test approach iteratively generates the set of candidate patterns of length $(K+1)$ from the set of frequent patterns of length K $(K \geq 1)$, and check their corresponding occurrence frequencies in the data base. The Apriori algorithm achieves good reduction on the size of candidate sets. However, when there exist a large number of frequent patterns or long patterns, candidate generation and test methods may still suffer from generating huge numbers of candidates and taking many scans of large data bases for frequency checking.

Recently, other category methods, pattern-growth methods, such as FP growth [11] and Trade projection [3] have been proposed. A pattern – growth methods uses the Apriori property. However, instead of generating candidate sets, it recursively partitions the data base in to sub-data bases according to the frequent patterns found and searches for local frequent patterns to assemble longer global ones. In [10] shows that H-Mine has high performance in various kinds of data, our performs the previously developed algorithms in different settings, and is highly scalable in mining large data bases. In [19] developed an algorithm termed – A Dynamic approach for frequent patterns mining using Transposition of Data base for mining frequent patterns which are based on Apriori algorithm and used Dynamic function for longest common subsequence. In [7] output from hidden Markov models into the association rule mining frame work, demonstrating the potential for frequent pattern mining in the field of scientific modeling and experimentation. New probabilistic formulations of frequent item set based on possible world semantics are introduced in [20]. In [17] a statistical approach to probability and all the items and all the transactions are independent is given. A class of models called Item Set Generating models (IGM) that can be used to formally connect the process of frequent item set to discover with the learning of generative models are presented in [20].

3. Model Description

We can calculate the set containing maximum number of peoples in a region who have contact with more groups in the society. Here we use the technique used in Dynamic programming. Finding the set contain one element to maximum set of people who have contact with more groups.

Take a region and form a set with the people in the region with a one –one correspondence with the set of natural numbers. i.e. Number the people in the region as $P = \{P_1, P_2, \ldots, P_N\}$.

Now collect all possible groups. So that each group contain persons in the set P. In a society we can find many groups which may be groups of people working in the same office, members of different religious groups, peoples in a club, group of people buying groceries from the same shop etc. Collect all possible groups and name it as $G_1, G_2, \ldots, G_M$.

4. Divide and Conquer Rule

Here we call the person who is in more than one group as frequent item as in Data mining. We can calculate all frequent item set with a certain number of state wise operations starting the problem from finding frequent item set with one person to maximum frequent item set, By the Dynamic programming (DP) procedure we divide the problem of finding set of maximum persons with contact in more than one group as various stages. In each stage we find the set of frequent item containing persons equal to number of stages. In each stage there exist some states. The decision sets of each stage is its

state sets which contain persons equal to the stage number and they all belongs to more than one group.
$\{S_k\}$ be the decision sets in the k^{th} stage. That is $\{S_K\}$ represents collection of all sets of K persons and they together belong to more than one group. The optimal policy for each stage is to find maximum number of set of persons and number of elements in each set is equal to the stage.
The optimum policy in the K^{th} stage can be written as

$$F_K^{(x)} = \max_m \{S_K\}^m$$

Where 'm' show the number of sets in the collection.

5. Finding the Priority Set by D.P. Procedure

Consider $P = \{P_1, P_2, \ldots, P_N\}$ be the people in a region; $G = \{G_1, G_2, \ldots, G_M\}$ be the possible groups where G_i subset of P $\forall \; i = 1, 2, \ldots, M$. First represent all groups in a table as follows.

	P_1	P_2	$\cdots$	P_N
G_1	x_{11}	x_{12}	$\cdots$	x_{1n}
G_2	x_{21}	x_{22}	$\cdots$	x_{2n}
$\ldots$	$\ldots$	$\ddots$	$\ldots$	$\ldots$
G_m	x_{m1}	x_{m2}	$\cdots$	x_{mn}

Table 1.

where $x_{ij} = \begin{cases} 1, & \text{if } P_j \in G_i; \\ 0, & \text{if } P_j \notin G_i. \end{cases}$

The total number of group in which P_1 is a member $= x_{11} + x_{21} + \ldots + x_m = \sum_{i=1}^{M} x_{i1}$. In general the total number of group containing the person $P_j = \sum_{i=1}^{m} x_{ij}$. The table of first stage is given by

Persons	Total group as a member
P_1	$\sum_{j=1}^{K} x_{j1}$
P_2	$\sum_{j=1}^{K} x_{j2}$
$\cdots$	$\cdots$
P_n	$\sum_{j=n}^{K} x_{jn}$

Table 2.

The first stage is to find all the sets with single persons belong to more than one group. In this stage the state variables are $P_1, P_2, \ldots, P_N$. The return function for P_i is

$$F_1(P_j) = \sum_{j=i}^{M} x_{ji}$$

If $F_1(P_j) > 1$, then P_j is a decision variables in the first stage. We remove all person P_k from the problem if $F_1(P_k) \leq 1$. Let the decision variable from first stage are the person $\{P_{11}\}, \{P_{12}\}, \ldots, \{P_{1q}\}$. Each person P_{1j} for $i = 1, 2, \ldots, q$ belong to more than one group. In the second stage our aim is to find all set contain two persons and they together belongs to more than one group. Each person in this sets must be the member of $\{P_{11}, P_{12}, \ldots, P_{1q}\}$. The state variable of second stage is the set of all sets of the form $\{P_{1i}, P_{1j}\}$ for all $P_{1i}, P_{ij} \in S_1$. Optimal solution for the second stage is given by

$$F_2(x) = \max_m \{S_2\}^m = \max_m \{S_1 \cup x\}^M \quad \forall \; x \in S_1 \;\; \& \;\; S_1 \in \{S_1\}$$

$$\sum_{K=1}^{N} x_k \left(P_{ij}/P_{1i}\right) = \begin{cases} 1, & \text{if both persons } P_{1j} \text{ and } P_{1i} \text{ are is } G_k; \\ 0, & \text{Otherwise.} \end{cases}$$

$\sum_{K=1}^{N} x_k \left(P_{ij}/P_{1i}\right)$ represents total number of group which contain both persons P_{1j} and P_{1i}. Table 3 represents the situation of stage 2.

	P_{11}	P_{12}	P_{13}	$\cdots$	$\cdots$	P_{1n}
P_{11}	$\cdots$	$\sum_{i=1}^{N} x_i(P_{12}/P_{11})$	$\sum_{i=1}^{N} x_i(P_{13}/P_{11})$	$\cdots$	$\cdots$	$\sum_{i=1}^{N} x_i(P_{1n}/P_{11})$
P_{12}	$\sum_{i=1}^{N} x_i(P_{11}/P_{12})$	$\cdots$	$\sum_{i=1}^{N} x_i(P_{13}/P_{12})$	$\cdots$	$\cdots$	$\sum_{i=1}^{N} x_i(P_{1n}/P_{12})$
P_{13}	$\sum_{i=1}^{N} x_i(P_{11}/P_{13})$	$\sum_{i=1}^{N} x_i(P_{12}/P_{13})$	$\cdots$	$\cdots$	$\cdots$	$\sum_{i=1}^{N} x_i(P_{1n}/P_{13})$
$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
P_{1n}	$\sum_{i=1}^{N} x_i(P_{11}/P_{1n})$	$\sum_{i=1}^{N} x_i(P_{12}/P_{1n})$	$\sum_{i=1}^{N} x_i(P_{13}/P_{1n})$	$\cdots$	$\cdots$	$\cdots$

Table 3.

Here $\sum_{i=1}^{N} x_i(P_{11}/P_{1n})$ means that the number of group the person P_{11} is a member in which already P_{1n} is a member. From stage 2 we get the set of all set which contain two persons both of them together belongs to more than one group. Continue the stage wise process by the solution variables from the previous stage as the state variables. The process stop when we get all set with maximum persons such that all elements in the sets together belongs to more than one group and their does not exist higher frequent item sets.

6. Conclusion

The method of dynamic programming (DP) was developed in 1950's through the work of Richard Bellman who is still the doyen of research workers in this field. The essential feature of the method is that a multivariable optimization problem is decomposed into a series of stages, optimization being done at each stage with respect to one variable only. Here an attempt is done to find optimal number of persons who have contact with a big group using D.P method. By calculating the optimal set of persons we are identifying those people, if they affect corona virus will be a great threat to the society. Many mathematical models are created by Researchers to solve these pandemic problems. By developing models related to this situation, researchers will help to find solution to various problems that affect the society due to the pandemic. From all models we can choose the best model. By these studies we can find the fault occurred in handling this situation.

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