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On Off Controller for COVID 19 Management

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Abstract - *World is under COVID 19 pandemic and has disrupted the normal life around the globe. This paper confirm that control engineers can have a stake in managing this pandemic. The pandemic is an unstable, open loop system. There are different techniques in controlling an unstable, open loop system in engineering. This same techniques applies to Covid management. As a case study, this paper considers data pertaining to Covid patients in Kerala from January 30, 2020 to May 5, 2020. A control system design with On off strategy to control two parameters that influences the number of Covid patients and predictive planning for COVID management based on this strategy are the highlights.*

Key Words: *Covid 19, On off Control, Curve flattening, Reproduction output, Mitigation, suppression, Lockdown, Duty cycle*

1. INTRODUCTION

This World is under COVID 19 pandemic. Time proves we are fighting against our own shadow. The entire mankind is trying hard to contain the unknown enemy and to grow. Understandably, the country which emerges with a successful exit strategy first will win and rule the globe. Epidemiologists, statisticians, biologists and health officials are the super men or super women whom all look for a resolution. Yet another community has a stake in formulating the exit strategy, and surely it is none other than engineers. Covid 19 is not is not all an engineering problem. But engineering has the power and capability to solve the problems of other domains too. Observe the pattern of Covid 19 pandemic. It is an unstable, open loop system. With no control, it grows exponentially. Theoretically all systems analogous to a control system, can be stabilized effectively and efficiently by applying the principles of control theory.

1.1 Challenges and problems in COVID management

Three important problems face us at this moment of crisis. They are:

1. How to diminish the rate of propagation of this virus?
2. How to bring the outbreak under control?
3. How far we can relax the social distancing for effective and economical functioning of society?

1.2 Reproduction Number (RN)

The basic reproduction number for Covid pandemic is high. This number depends upon the density of the community, general health of the population, its medical infrastructure, resources and the response of the community. With Covid pandemic, fatality rate has gone up. Fatality rate is also variable and depend on many factors such as age, physical fitness, present pathologies, region and access to health care. A large percentage of people who contract the disease develop a viral pneumonia. Many patients require artificial ventilation. If the number exceeds the capacity of Intensive care units to accommodate them, fatality rate will increase. Demand for flattening the curve arise from this. A high sharp curve show a surge of infections in a brief time period.

Mitigation and Suppression are the two approaches followed throughout the world for containing this pandemic. Mitigation focuses on slowing, not stopping the spread. Suppression aims at reverse epidemic growth. For mitigation RN reduces but remains greater than 1. For suppression, RN is smaller than 1.This is accomplished by implementing lockdown, by restricted travel, home confinement, social distancing, etc. These restrictions are Non Pharmaceutical Interventions.

2. Engineering the Control

This is the point where the control engineers can interfere. A systematic strategy based on feedback can be designed to change RO through the modulation of NPI's. The strategy alternates between suppression and mitigation to maintain the spread at a desired level. There are many challenges.

1. Covid 19 is a very peculiar disease.
2. Biologists still do not know why some people experience fairly mild symptoms while others feel the extreme.
3. No one can explain why men are facing more fatality.
4. There is a long incubation period of 14 days between infection and symptoms.
5. Even persons can get re infected.

The long incubation time and apparent spreading of the virus before symptoms are experienced undoubtedly contribute to the relatively high RO values. This is because infectious people continue to interact with others and transmit the virus without knowing that they are doing so.

This lag in onset of symptoms corresponds to time delay in control system theory. This slag introduces oscillations into closed-loop systems.

In addition, there are very significant uncertainties.

1. Testing process can cause inconsistency.
2. The extent to which public complies with policies is never 100 percent and may not be measurable.
3. Health care capacity may vary for many reasons.

3. Covid Control in Kerala

Kerala is the southernmost state of India which fascinated the world with its remarkable achievement in public health. India confirmed the first coronavirus case in Kerala on January 30, 2020. Since then Kerala has been fighting the pandemic in an exemplary manner. It was on this day when UN declare health emergency on coronavirus. The activities of Kerala government and the state departments resulted in flattening the curve of covid cases on during the week April 30 to May 5. Thousands of people from outside had returned to Kerala by various means of air, sea, road and rail. But, suddenly trends are indicting a rise in cases in Kerala. It is because we have unfamiliar processes, systems, disturbances, measuring elements, various inputs and various outputs.

3.1 Developing a Closed Loop Control System

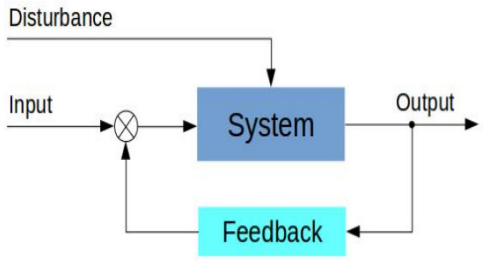

Figure -1 Closed Loop Control System

Control system in which the output influences the input quantity in such a manner that the input quantity will adjust itself based on the output generated is called **closed loop control system**. **Open loop control system** can be converted in to closed loop control system by providing a feedback. The covid pandemic which is an open loop system is converted into a closed loop system by testing COVID positivity. This information is used as a feedback for comparison with reference for modifying the parameters in control strategy. Here the output is Actual Number of Covid Patients. Input is the Zero Covid Patients. Number of Covid patients detected by testing is compared with input. If the comparison result is negative, the system has to be controlled as shown below.

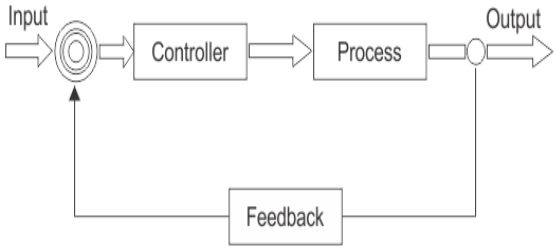

Figure 2: Closed Loop Control System

3.2 Parameters to be controlled.

The number of COVID patients can be brought down only by controlling certain parameters which affects in rising the COVID patients. The key parameters are

1. social distancing
2. the inflow of people from other locations

3.3 On off Control strategy on COVID management

On off approach on Social distancing measures: Here some restrictions are lifted when the number of fresh cases requiring intensive care is below a threshold and are put into place when it exceeds a certain number. The feedback variable in this case is the number of COVID patients in hospitals.

On off approach on Inflow of people into the state: Restrictions on travel, too, can be variable. Full lockdown limits people to moving within the boundaries of their property. But as conditions improve, the officials may allow people to move. People coming from affected areas need to be controlled. The feedback variable is the number of COVID patients in hospitals

3.4 CASE STUDY – KERALA

On March 9, 2020 the covid cases started increasing. On March 25, the state implement Lockdown. During the initial phase of lockdown the cases rose in numbers and gradually got decreased. It showed a decrease or substantial nil cases during the first week of May. May 6 is the demarcating point. From May 7, inflow of outsiders into Kerala started. Subsequently, the covid cases grew in numbers.

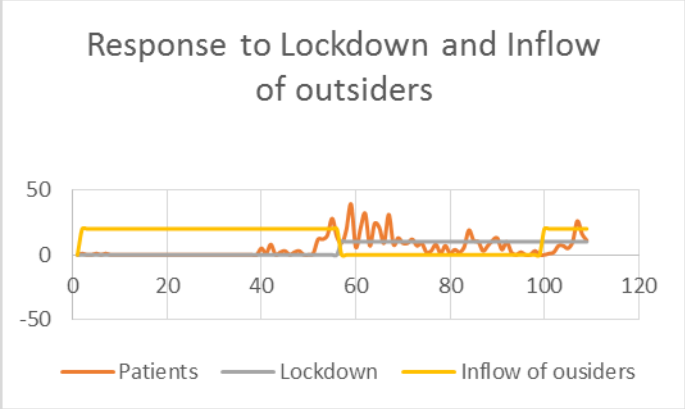

Chart -1: Response of Lockdown and inflow of outsiders

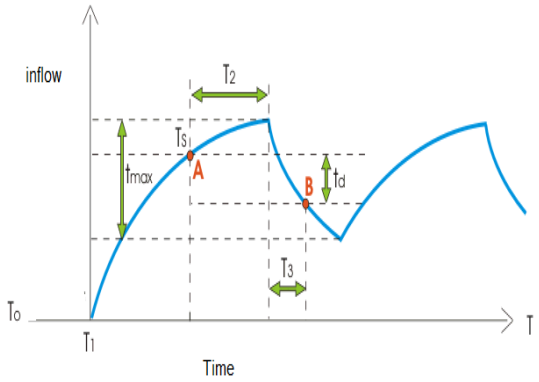

Figure -3: Analysis

Say at time T_0, restrictions to enter the state is lifted. The COVID 19 test will not be responding instantly, as it requires some time delay for the lengthy incubation period of 14 days between infection and symptoms. Say from instant T_1 number of COVID positive patients' starts rising. This rising is exponential. At point A, the **(control)** system has to reduce the inflow by putting restrictions on entry to the state and finally after a period of T_2 the number of patients decreases exponentially. At point B, the (control) system shall start lifting the restrictions for entry. And after a period of T_3 number of covid patients will start rising in the same exponential manner. So if the slope of the curve is to be reduced, the duty cycle should vary or the period of lifting and putting restrictions on entry should vary. The point A and B shall be determined based on the medical infrastructure available across the state.

3.4 What actually happens?

By adjusting the duty cycle of putting ad lifting the restrictions, we are adjusting the RN. The convenient RN is to be determined by considering the medical infrastructure available.

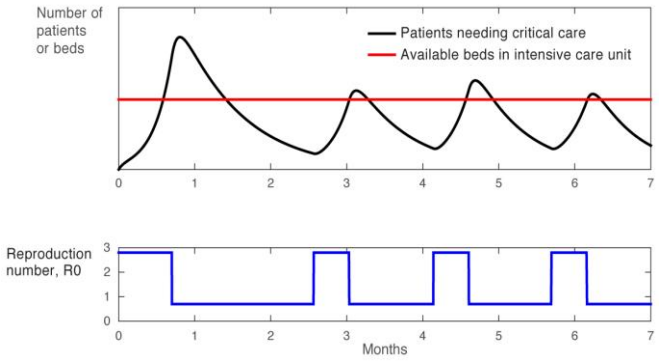

Figure 4-Duty Cycle of the controller

4. CONCLUSIONS

Covid 19 management becomes effective by utilizing controlled lockdown to reduce social distancing for weaker sections. Kerala has now controlled the COVID 19 pandemic and has developed its own health management strategy. In such a case, On Off control strategy could be applied to control the inflow of Keralites from outside to control the RO which should not go beyond the stage which demands excessive medical infrastructure. Also based on this model, a job sector of hospital tourism is developing and is the right time to start.

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