Condition Based Maintenance Model

There are several components for each device (e.g., Tires, Engines and Hydraulics). We must make sure that they are all function components, which implies a series systems. Meanwhile, the combining inspection and maintenance actions between the machines can also yield a lower total cost than inspecting or maintaining a single component, which implies the economic dependence between components.

The maintenance strategy in our problem is condition-based maintenance (CBD), which has been widely accepted in recent decades. Comparing with another strategy, time-based maintenance (TBD), which makes decision based on historical data, CBD recommends maintenance decision based on the current condition of the devices. Condition-based maintenance can be a more efficient strategy, as it reduces unnecessary maintenance actions and eliminate the risks associated with preventive maintenance actions.

Since CBD makes decision based on current condition of the devices, the inspection plays an important role in the maintenance optimization. Appropriate inspection frequency could reduce the maintenance cost. Another question in inspection is the inspection quality. It is hard to make sure the accurate of the result of the inspection in practice. If the inspection gives information with mistake, the maintenance decision would be affected. With more high-tech inspection devices implemented in mining practice, we assume inspection quality is perfect, while inspection frequency is another decision that we are going to optimize.

The probabilistic maintenance model can roughly be divided into two parts: a deterioration model and a decision model. The deterioration model estimates the uncertain time to failure and the transition probabilities between different states, and the decision model uses the deterioration model to determine the optimal time and action of inspection and maintenance.



The first part of our model is the deterioration model. In recent years, a lot of research has been conducted on the prediction and estimation of deterioration model. Normally, some partially observable data histories are available, but different type of historical data fits in with different models. In our decision model, the inspection frequency is non-periodic inspection, so the data comes from unequal observation intervals, some transitions would be unobservable. Without complete information of the system, the Expectation & Maximization algorithm will be used to estimate the transition probabilities.

The second part of our model is the decision model. Both maintenance and inspection decisions would be made, and through the inspection process, we can collect the states of the system, which can be used in the deterioration model. The stochastic dynamic programming model or discrete-time Markov decision model that we will use for making decisions has been widely applied in maintenance, inventory and telecommunication among others.

The combination of these two models can continuously make decisions and generate required data to update the system condition.