Dynamic Optimization in A Dynamic Industry

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Every engineering problem in life (with appropriate objective function, constraint functions, variables and parameters) can be defined as an optimization problem (The only limitation is our imagination). Things that are not optimally designed (product, system, etc.) either do not work, or work inefficiently and cannot be sustainable. Everything has a life-cycle, the issue is to extend its useful life. The only thing that distinguishes the civil engineer from the other building builders is to make optimally designed buildings. The same thing applies to those who design and operate machines, circuits, plants...However, in many engineering departments optimization is not taught at all!

In the majority of optimization problems, it is assumed that the problem parameters, variables, constraints, and problem definition set are precisely known beforehand and do not change during the process. Is this assumption true for real life problems? Certainly not! We are accustomed to hearing this statement: "This job is very URGENT !!!"...or "One of the machines have been broken down. Revise the plans"...similarly, "We got new orders and some were canceled. We need to optimize the plan again. In the meantime, do we have enough time and resources?". Branke and Schmeck (2003) reported that: "However, almost all publications deal with optimization in static, non-changing environments, whereas many real-world problems are actually dynamic: new jobs have to be added to the schedule, machines may break down or wear out slowly, raw material is of changing quality, etc.". In a more recent study, Nguyen, Yang & Branke (2012) indicated that: "Optimization in dynamic environments is a challenging but important task since many real-world optimization problems are changing overtime." So, what is the dynamic domain (environment)? In this context, what is the Dynamic Optimization Problem (DOP)? What are the main differences with other problems? Some typical examples can be easily found in production. New job arrivals, job cancellations, machine failures, changes in production constraints, changes in lot sizes, delivery times, changes in short-mid-term plans such as job-work assignment, production planning, are some frequently encountered dynamic events in real life production systems. The characteristic of these events is that, they cannot be known precisely and cannot be easily predicted. In general terms; the domains that change over time (time-varying) or change via some events (event-based) or time-varying variants are defined as dynamic environments (Branke, 1999; Branke & Schmeck, 2003). The problems with these features are referred to as dynamic optimization problems (DOPs) in the related literature. Nguyen et al. (2012) define a DOP as "Given a dynamic problem f_t, an optimization algorithm G to solve f_t, and a given optimization period $[t^{begin}, t^{end}]$, f_t is called a dynamic optimization problem in the period $[t^{begin}, t^{end}]$ if during $[t^{begin}, t^{end}]$ the underlying fitness landscape that G uses to represent f_t changes and G has to react to this change by providing new optimal solutions." Numerous other general definitions for DOPs can be found in the related literature.

In this talk, several real life industrial applications of dynamic optimization from our previous studies are presented. These include; dynamic scheduling of heat treatment furnaces, dynamic part family formation for cellular manufacturing, dynamic scheduling of flexible manufacturing systems with flexible transportation abilities, dynamic load consolation for transportation operations, dynamic optimization of several CNC operations etc.