STRUCTURAL COMPLEXITY METRICS APPLIED AGAINST PRODUCT GRAPHS

Predicting Market Price and Assembly Time from Function and Assembly Models

CHERKADU VASALA SRI RAM MOHINDER, SRIDHAR SUDARSHAN, JOSHUA D. SUMMERS
Clemson University, USA

1. First Order Headings

The objective of this research is to understand and identify key complexity metrics of different product model graphs (assembly models and function structures) that can be used for surrogate modeling of product performance metrics (assembly time and market cost). Previous work has shown that complexity metrics applied against graph topologies can be used to create predictive models of assembly time given product assembly models (James L Mathieson, Wallace, & Summers, 2013; E. Namouz & Summers, 2013; E. Z. Namouz & Summers, 2013; E. Owensby et al., 2011; J. E. Owensby, Namouz, Shanthakumar, & Summers, 2012) and market cost given function structures (J L Mathieson et al., 2011). This previous work has shown that historical data in the form of product graphs reduced to a vector of twenty nine complexity metrics coupled with performance metrics can be used for performance prediction through artificial neural network surrogate modeling. Building on this preliminary work, we will try to understand why these surrogate models work. We hypothesize that some complexity metrics are significant predictors for both market price and assembly even when applied against disparate models such as the function structures and CAD assembly models. To begin to develop a fundamental understanding of how the structure within a graph contains hidden information such as cost and time, we first begin by constructing four different base prediction models: Function Structures to predict Market Price (FS-MP), Assembly Models to predict Assembly Time (AM-AT), Function Structures to predict Assembly Time (FS-AT), and Assembly Models to predict Market Price (AM-MP). These four prediction models will be created with a common database of products with the graphs, and their associated structural complexity vectors, and the performance values externally defined when possible to ensure objectivity in the research. These products will be consumer electro-mechanical products, such as power tools, kitchen appliances, and children's toys. Once the prediction models are created through the use of artificial neural networks (ANN), we will analyze the level of significant contribution of each metric to the prediction model. We will explore both principle component analysis and linear and nonlinear regression analysis to refine the complexity metric vector.

The hypotheses that we explore:

1. Topological Complexity can be used to predict performance metrics (new exploration with different inputs and outputs).
2. Different graph sources will yield different accuracy and precision of results (FS< AM)
3. Different performance metrics will be predicted with different accuracy and precision of results (MP < AT).
4. A collection of diverse complexity metrics is required to develop good predictive models.
5. A sub-set of complexity metrics will be found to be significant in all permutations of input-output predictive models.

References

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