Multidomain Demand Modeling in Design for Market Systems

by

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ABSTRACT

Multidomain Demand Modeling in Design for Market Systems

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Design for Market Systems (DMS) research has aimed to develop enterprise-level design optimization approaches linking consumer demand and engineering design. Applying demand models to engineering optimization has allowed a design objective to consider enterprise profit beyond engineering performance. However, most demand models in DMS are based on conventional discrete choice analysis (DCA) that is limited to functional product attributes decided by engineering design decisions.

Consumers make choices based not only on functional product attributes (e.g., fuel economy) but also on non-functional attributes (e.g., vehicle form). Consequently, ignoring non-functional product attributes in demand modeling can lead to product designs less attractive to consumers. This dissertation focuses on two major non-functional product attributes: (i) aesthetic product form as a *perceptual product attribute* and (ii) services as *external product attributes*.

The issue with non-functional attributes is that they are not typically controlled by engineering designers. Instead, these attributes may be decided by designers in different domains such as industrial, service, or operations design.

A separate or sequential decision making in each design domain is not effective

if the design domains share design variables that lead to trade-offs between the domains' decisions. This dissertation offers a quantitative methodology to interface and reconcile decisions within different domains and guide the design process to balanced decisions.

A limitation in conventional DCA is that it handles functional and non-functional attributes within a single demand model. An aesthetic product form is generated by a potentially huge number of geometric variables; thus, it cannot be quantified simply and it is difficult to integrate with functional attributes. Similarly, when considering services, it is challenging to incorporate the relationship (or channel) between product and service attributes (or multiple providers) into a single demand model.

This dissertation proposes a multidomain demand modeling approach to integrate functional and non-functional attributes, whose values are decided by different design domains, into a single demand model. We employ consumer choice models from Marketing, systems design optimization from Engineering, machine learning algorithms and human-computer interaction from Computer Science, and location network models from Operations Research within a design optimization framework. This work addresses three demand models: (i) a demand model for engineering and industrial design, (ii) a demand model for engineering and service design, and (iii) a demand model for engineering and operations design. The benefits of this unified approach is demonstrated through three respective design applications including gasoline vehicle design, electric vehicle and charging station location design, and tablet and e-book service design.

The contribution of this research is in helping resolve trade-offs between conflicted design domain decisions, by integrating disparate attributes into a multidomain demand model. This work consequently extends the scope of Design for Market Systems from product design to business model design by considering external product attributes.