Novelty and Reuse in an Open Innovation Community

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Summary

Open innovation platforms store data that can be used to study the evolution of designs in the open. Network science can be applied to further our understanding of design inheritance. Objective methods of distance between designs based on their form and function can also help us understand the differences between proposed designs, and their prospective use and reuse.

We combine network analysis methods with objective methods of distance between product designs in an open innovation community to understand how specific attributes of the artifacts reused in the creation process may affect the usage of the newly created designs. The two distance measure methods capture the differences between designs in terms of their (i) shape and (ii) function. The general finding, based on analysis of a large product network of 3D printing designs, is that strategies of heterogeneous inheritance are usually better than pure strategies. Designs inheriting from a combination of novel and imitative designs do well, as do designs that are created near to some inherited designs and far from others. These findings provide insights into the current affordances of a large open innovation community and suggest ways of architecting better systems to support these communities.

Introduction

Open innovation communities provide a platform for people that are not part of a formal organization to use, refine and reuse digital artifacts (Kallinikos et al. 2013; Majchrzak et al. 2004). The reuse of digital artifacts has lead to the development of wikis (Majchrzak et al. 2006), operating systems (Lakhani and von Hippel, 2003), and music (Cheliotis et al. 2014). Remixing as a form of digital artifact reuse provides a way of tracing innovation processes and detecting the emergence and evolution of designs. This study analyzes the creative methods of product designers in an online 3D printing community (thingiverse.com), where participants freely exchange, modify or reuse existing designs. We focus on the inheritance structures of the innovation process. As part of this work, we use computer graphics and natural language processing methods to respectively measure the (i) shape and (ii) semantic novelty of proposed designs at the time of their introduction. In addition, we use qualitative research methods to examine how search and combination efforts of lead users might differ from other users.

Methods Used

In the product design literature, products are often discussed in terms of both form and function (Bloch 1995). Differences in shape will have an impact on the behavior of those interacting with the objects (Creusen and Schoormans 2005; Luchs et al. 2008; Rindova and Petkova 2007). In this study, we focus on two types of novelty, shape and semantic novelty.

The distance between shapes is calculated using a variation of a computer graphics method (Kazhdan et al. 2003) for measuring the shape distance between product designs. The algorithm represents each design based on spherical harmonics (Müller 1966), in order to obtain rotation and size invariant characterizations that can be used to calculate distances that fairly represent changes in shape rather than changes in perspective.

Besides shape distances between products, examining the semantic distance (Rips et al. 1973) between products can allow us to understand the extent to which they differ. In addition, in a longitudinal examination of product designs, we can understand how these designs evolve. Another benefit of quantifying the distance between product designs is that we can measure the degree of *semantic novelty* (a form of *cognitive novelty*, see Kaplan and Vakili 2014) of a proposed design upon its introduction. We use topic modeling, which allows us to discover the latent topics in a collection of product descriptions. As each product description is composed by a series of topics, we can measure the differences between designs according to their differences in topic composition. The designs that are dissimilar to any preexisting design can be characterized as novel. By introducing these new measures of shape and semantic novelty, we can also compare the relationship between shape and semantic novelty.

This research is an observational study of the collective efforts of more than 8,000 designers who contributed 35,727 product designs. Archived sequences of contributions from designers are quantitatively and qualitatively analyzed to understand the importance of reuse and the learning process of users.

Innovation as a Search Process

Design has often been seen as a search (Benner and Tushman 2003; Gupta et al. 2006; March 1991) through space. Using an objective, repeatable measurement of shape distance in a 3D collective design online community, an empirical fitness landscape is created. From this landscape, shape novelty is computed. The relationship between novelty and design practicality measured by the number of times a design was manufactured is assessed (Figure 1A).

In the case discussed, very novel designs in terms of their shape were manufactured 1.9 times more than very imitative designs. This result is particularly noteworthy because the instantiation of product designs can be seen as an indication of utility. In most studies of creativity, novelty is thought to

tradeoff with utility: in this community, novel designs have better outcomes. The evaluation of the community members may be acting to highlight designs that are both novel and useful.

Innovation as an Anchoring Process through Reuse

What theories might be applied to help understand how community members strategically use reuse features? One plausible set of theories comes from the strategic management literature, and involves search (Benner and Tushman 2003; Gupta et al. 2006; March 1991). These theories have recently been applied to crowds (Afuah and Tucci 2012), the new insight being that crowds provide a way to transform distant search into local search. Since crowds are diverse, there is a chance that several members of the crowd will have extensive local knowledge in many areas of the design space. This echoes other theoretical work which points out the value of diversity in collective processes (Page 2008).

Open innovation communities provide features that encourage the modification and reuse of designs. Designs that built upon only one prior design were more used when that design was a previous creation of their own. Designs were also more used when they built upon multiple previous designs. In addition, designs created near to some inherited designs and far from others were manufactured more than those created with alternative strategies (Figure 1B). These findings suggest ways of architecting future open innovation communities.

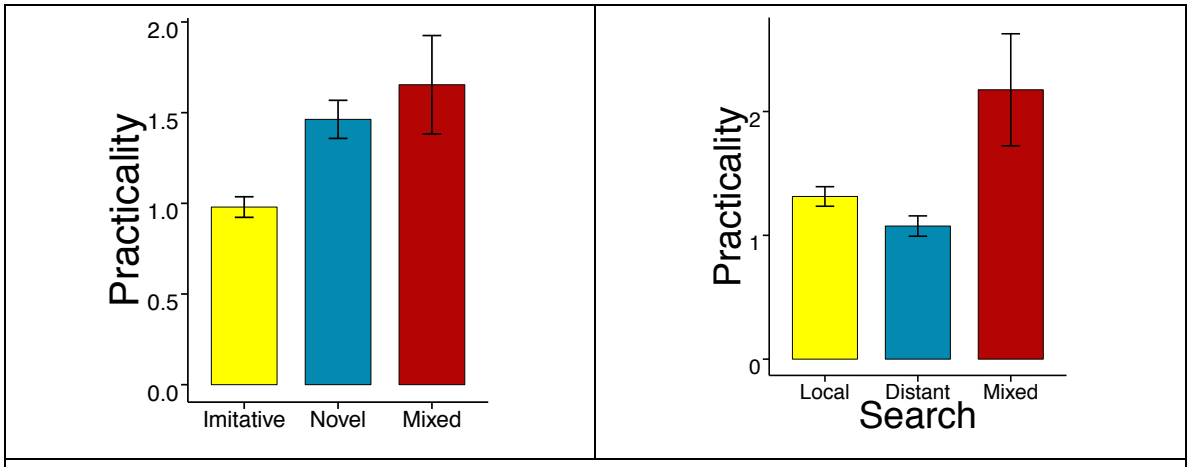

Figure 1A. Novel and Imitative Parents (Left). The designs were classified as (i) imitative when all of their parent designs were not novel, (ii) novel when all of their parents were novel and as (iii) mixed when they inherited from both novel and imitative designs. Error bars represent standard error of the mean. **Figure 1B. Designing close to or far away from parent designs (Right).** Designers that combined designs similar to the final design with designs that were somewhat distant created more practical product designs (measured by how often the products were manufactured). Error bars represent standard error of the mean.

The Interplay of Novelty & Reuse on Measures of Use

The interplay of novelty and reuse is assessed. Our results confirm the importance of both for the final usage of designs (Figure 2). The number of times a product design was manufactured was used to assess the usage of a proposed design. An empirical fitness landscape shows how (i) digital artifact reuse, (ii) novelty and (iii) their interaction affect the use of contributions in an open innovation community.

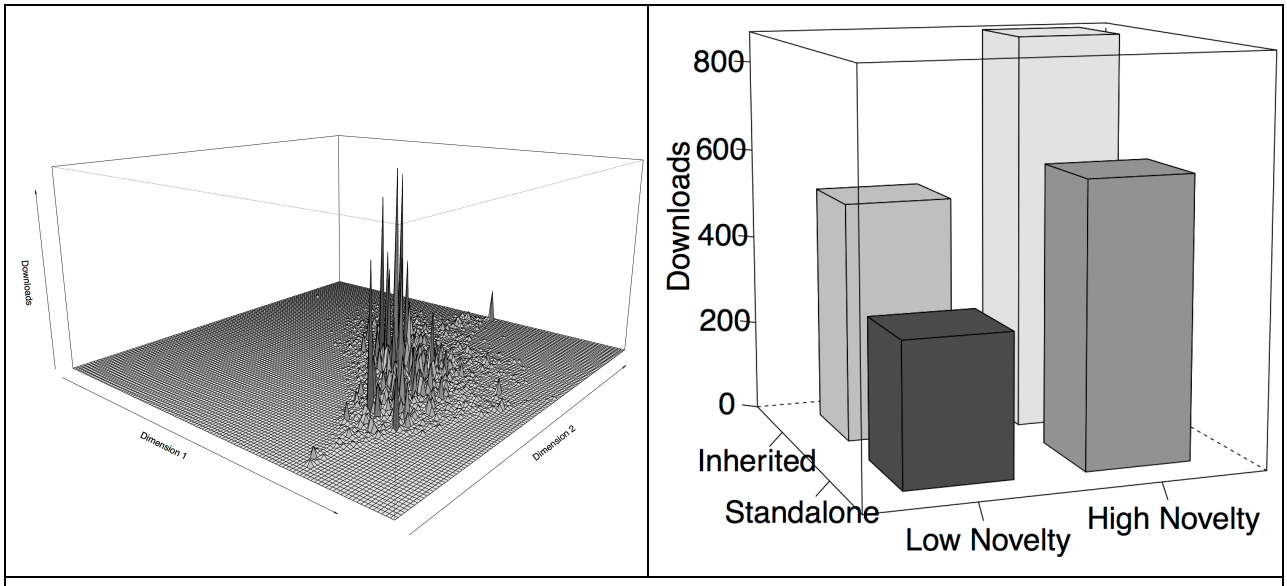

Figure 2. Empirical Landscape and the Interplay of Novelty and Reuse. Left figure shows the maximum value of downloads in each of 11,877 segments of the design space. Right figure shows the average number of downloads with respect to its degree of shape novelty (low or high) and the reuse of prior designs (standalone or inherited).

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