Design is Everywhere, But Nowhere in Patent Analytics

Taek-Kyun Shin
Jieun Kim

20–33

The number of design patents has grown significantly in the last 140 years. However, a data-driven approach for design patents has been overlooked and underutilised in the design management and innovation research communities. Through the prism of a patent professional, data analyst and designer, this photo essay demystifies the complexity of design patent data and sheds light on the underlying value of design as it features among a range of diverse innovation activities. Patent network analysis and visualisation techniques enable the building of a series of patent citation maps and co-inventor networks. Cases from renowned companies—Apple, Dyson, Samsung, and LG electronics—reveal different shapes of innovation activities, focusing on product diversification strategies, collaboration patterns and design-technology cross-pollination flows.

#network visualisation

#patent analytics

#design patents

#intellectual capital

#gephi

Introduction

Design management is a rigorous and strategically anchored mechanism to capitalise on the investment in design as intellectual capital. (Borja de Mozota and Valade-Amland 2021, 6)

The value of design has never been more heralded as promising economic benefits, nor has it been regarded as a competitive investment for tech businesses more widely than it has now (Maeda 2017). Despite this intensifying focus on design, the recognition of pertinent intellectual capital assets— design patents more specifically—and their strategic uses in innovation management have seldom attracted scholarly attention. In particular, data-driven approaches for measuring the value of design patents as a proxy for innovative activities are underrepresented in research on the subject (Kim et al. 2021).

The importance of protecting designs was first recognised in the Paris Convention for the Protection of Industrial Property in 1883. Since then, the volume of design patents has steadily increased. A seven-year-long design war between Apple and Samsung (2011–2018) ignited a greater traction in design patents. Every year, around 800,000 design applications are filed worldwide, with an annual growth rate of 7.3% (WIPO 2020).

Designs are defined in the European Union Intellectual Property Office (EUIPO) as "the appearance of the whole or a part of a product resulting from the features of, in particular, the lines, contours, colours, shape, texture and/or materials of the product itself and/or its ornamentation" (Article 3 of the Design Regulation). The United States Patent and Trademark Office (USPTO) defines a design as an article that "consists of the visual ornamental characteristics embodied in, or applied to, an article of manufacture" (35 U.S. Code §171). On the legal front, designs are called *community designs* in Europe and *design patents* in the US, though the protections that these patents afford and the exact requirements that they entail are not identical across these two contexts. In this paper, for the sake of simplicity, two terminological correlates, *design patents* (i.e., *community patents* in Europe) and *technology patents* (i.e., *utility patents* in the US, 'patents' in Europe) will be employed.

While extant research examines the issues which arise in the midst of a fragmented international design-protection system, placing an overemphasis on the visual appearance of a design (Filitz et al. 2015; Yoshioka-Kobayashi et al. 2018), design patents in themselves have yet to be subject to data analytic techniques, despite the clear advantages of doing so. Firstly, design patents contain rich, objective data, such as the names of inventors (or designers), applicants, product classifications, drawings, and citation information, which are recorded at a level similar to technology patents. Second, only a few companies make their design teams and lead designers known, since they often keep the details surrounding internal organisation secret. Design patent data related to the inventors, and the subsequent network analysis which result from the scrutiny of this data, enable speculation regarding the patterns of collaboration between target companies' and core inventors, as well as the evolution of innovative collaborations (Trippe 2015). For instance, in the recent lawsuits surrounding the iPhone, court documents and Apple's patent filing history unravel the long, mysterious story of Apple's innovation team (Kim et al. 2021).

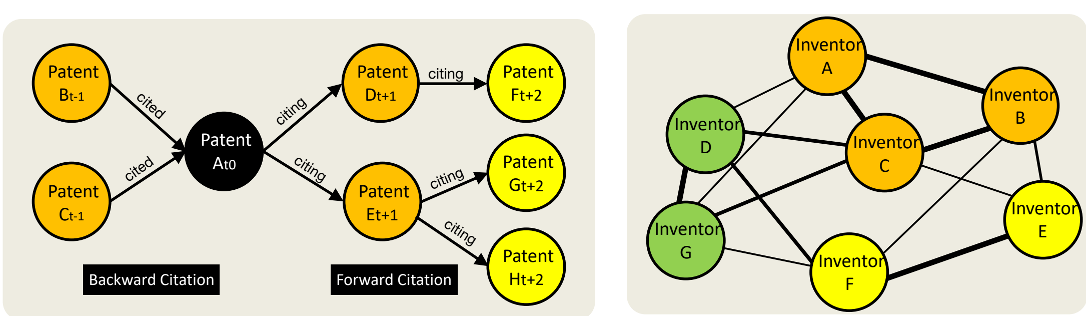
Considering the increasing strategic importance of design patents, this study addresses the following important question: Do design patents play a role in explaining the different shapes of design innovation activities? In particular, this study investigates the meaning of citations and co-inventor data in design patents through a network lens, with reference to cases from renowned companies—Dyson, Apple, Samsung, and LG Electronics. A series of patent network maps are sketched to chart the different shapes of their innovation activities and shed light on the underlying value of design in their product diversification strategies, design–technology pollination flows and collaboration patterns. Finally, this novel approach attempts to explore and to supply highly detailed, accurate and actionable insights on design patents to bolster informed decision-making in the design management and innovation research communities.

Research Method: Network Analysis and Visualisations

Network analysis and visualisation have been widely used for interpreting complex systems from multiple perspectives, ranging from social systems to shared knowledge networks (Prell 2012). A patent citation network is of great relevance to network analysis, specifically for forecasting emerging design (or technology) and innovation trajectories. Co-inventor networks investigate knowledge flows and collaborative patterns (Kim and Kim 2019).

At its most basic level, a network consists of sets of nodes (also called vertices or actors) that are connected through sets of edges (i.e., links, ties, or arcs) (Prell 2012). The edges can be either directed or undirected. In the case of patent citation networks (see figure 1a), the nodes represent patents, and the edges with arrowheads depict the directionality of backward and forward citations over time (i.e., the citing and cited relationships of patents). By juxtaposition, a co-inventor network consists of the nodes representing inventors and the edges that share the inventive relationships among inventors (see figure 1b). Suppose three co-inventors (inventors A, B, and C) are involved in the formulation of patent A and two co-inventors (inventors C and D) for patent B. The co-inventor network can be undirected, as there is no difference between the statements "inventor A worked with inventor B" and "inventor B worked with inventor A." In addition, thicker lines indicate the relative strength of links among the inventors, and colour codes are often applied to different clusters in the design/technology category.

A four-step patent network analysis—data collection (Step 1), data cleaning and mapping (Step 2), network analysis (Step 3), and network visualisation (Step 4)—is employed. Step 1 is to select the source of the patent data. Many national and regional patent offices provide digitalized patent documents, notably WIPO's Patentscope and



a Patent Citation Network

b Co-inventor Network

Figure 1: A conceptual representation of patent network analysis. *Source: authors.*

USPTO's PatentsView. However, raw patent data is notoriously riddled with misspellings, inconsistent data formats, as well as many terms which share the same or similar meanings, all of which lead to the necessity of thorough cleaning-up and standardization on the part of the research that wishes to subject to this data to an accurate analysis, which occurs in Step 2. In Step 2, data cleaning and mapping, the nodes and edges of a network need to be defined in a separate excel sheet as defined above. In Steps 3 and 4, a patent network analysis and subsequent visualisation are conducted with open-source software, Gephi v.0.9.2. Gephi offers various statistics to assess the overall structure of a network and identify which nodes play a central role in network measures (i.e., degree centrality, betweenness centrality, network density, network diameter, clustering). In this paper, however, the statistical analysis of network data falls short. Instead, the following photo essay focuses on how network-based patent analytics visually explain the different shapes of innovation activities assumed by the cases drawn from the likes of Dyson, Apple, Samsung and LG electronics.

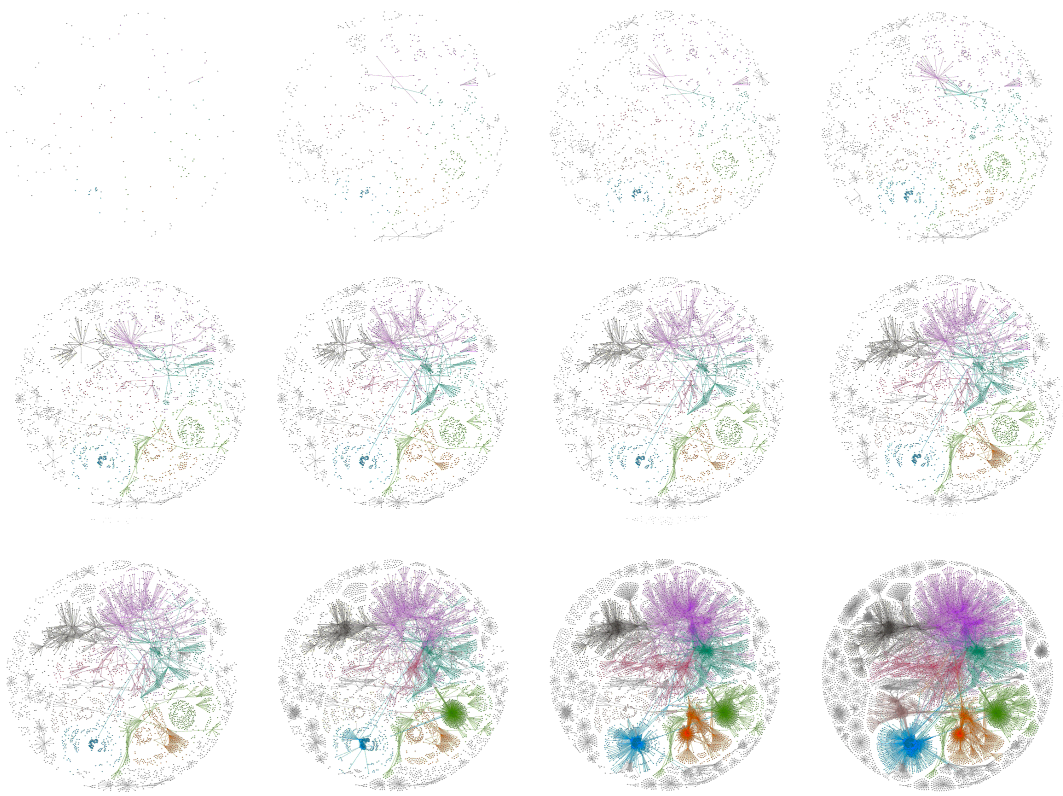


Figure 2: Evolution of Dyson's patent citation network by product category (2001–2018). *Source: authors.*

Product diversification from bagless vacuum cleaner to bladeless hair dryer: Dyson

Figure 2 explores the evolution of product diversification at Dyson, from its bagless vacuum cleaner to its bladeless hairdryer. Multi-depth patent citation networks allow us to both quantitatively and visually assess how Dyson's product innovations grow and are connected. Dyson published 624 patents (432 technology patents and 192 design patents) from 2001 to 2018, all of which can be broadly arranged into six main product categories: vacuum cleaners, fans, robot vacuums, motors, hand dryers, and hairdryers (Kim and Kim 2021). Each node (here, a patent) is sized proportionally to its number of citations, and is interconnected with each other through edges (i.e., citations). The network consists of large and small clusters of related patents. Colour codes are applied to different clusters in the product category: vacuum cleaners in orchid and teal, fans in blue, motors in orange, robot vacuums in black, hairdryers in coral, and hand dryers in green.

Dyson's patent network was highly fragmented in the early innovation stages (2001-2007), and many patents stand alone. However, since 2008, a few pairs and triads start to appear in isolation. With the naissance of one large cluster in the upper centre in 2011, at least three smaller clusters begin forming and are loosely interconnected, like islands. The largest and most densely connected cluster appears in the vacuum cleaner category, covering over half of Dyson's total filings. This cluster primarily links two types of vacuum cleaners: the first generation of the canister type (in orchid) and the upright type (in teal). Left, next to the vacuum cleaner cluster, there is a small-sized cluster, relating to robotic vacuum cleaners (in black). This relative position implies that the robot vacuum innovation has evolved by borrowing or improving many of designs and technologies derived from the vacuum cleaner category.

Interestingly, Dyson's signature product, the bladeless fan, is placed at the bottom of the network (in blue). The initial fan cluster was barely perceptible in 2008 but has consistently grown since then. A series of bladeless fan-like designs are placed in this cluster, including tower-type fans and other multifunctional products, air purifiers, humidifiers, and heaters. This bluish cluster is quite disconnected from the vacuum cleaner cluster in the network but is closely connected to the hairdryer (in coral) and hand dryer clusters (in green). Considering the position and connectedness of the clusters, the bladeless fan cluster is initially influenced by the hand dryers and exerts further influence upon the latest supersonic hairdryer. A complete map of Dyson's patent citations can be found in Figure 3.

Innovation pollination in design and technology: Apple

Can innovation be cross-pollinated between design and technology? Apple is known for harnessing technology and design to create substantial innovations in the market. Figure 4 and Figure 5 are Apple's patent citation network maps, based on all of the design and technology patents published by the company between 2001 and 2020 in the US. The ratio of technology to design patents was 11:1. Each node represents a patent and is proportionally sized based on betweenness centrality. Betweenness centrality measures the influence of nodes in a network relative to the flow of information between others (Prell 2012). For instance, nodes with higher betweenness centrality tend to hold more control over information flows through the network; they acquire new information easily, as more information will pass through that node, like a "brokering" or "bridging" role in a network. Apple's patents were subsequently colour-coded according to the following three innovation areas: hardware (in blue), product design (in orange) and User Interface (UI) (in yellow). Patents from other companies that are cited by Apple remain grey.

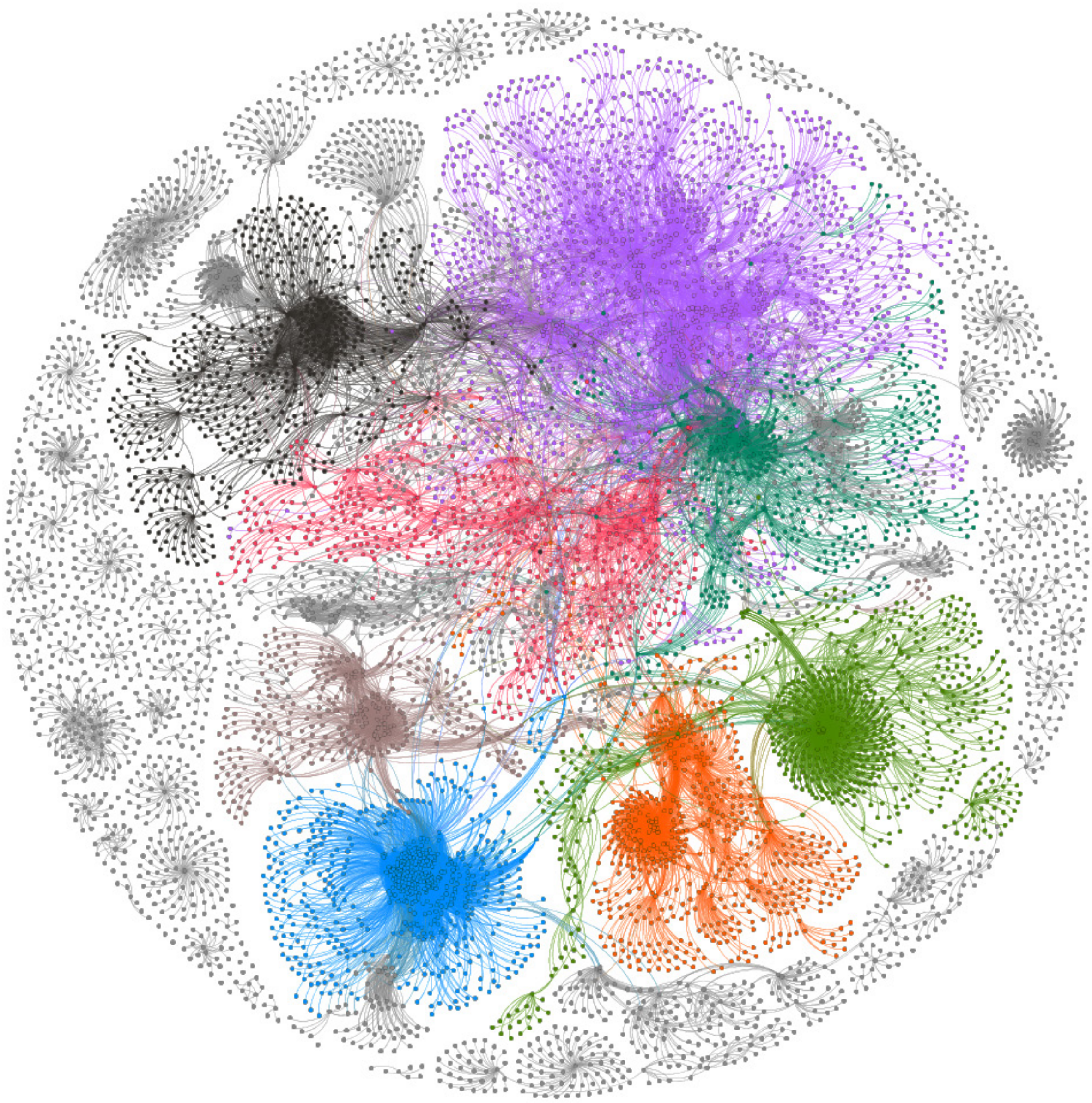


Figure 3: Overview of Dyson's patent network map (2001–2018). *Source: authors.*

Apple's patent citation networks are evaluated through a more granular lens, with the intention of discovering how Apple's hardware, product design and UI emerge and remain closely intertwined over time. Given that Apple's patent citations create a very large number of nodes and edges, the network starts with an overly dense, practically unreadable graph. The Yifan Hu graph layout, however, positions the linked nodes closer while pushing unrelated nodes farther apart.

Figure 5 shows that the UI cluster serves as the key connector between product design and hardware development. Its size and relevant position indicates that the UI design plays an important role in keeping Apple's hardware and software design aligned with one another.

Same-but-different design innovation teams: Samsung and LG

For nearly fifty years, Samsung and LG Electronics have been in fierce competition to take the lead in the consumer electronics market. The rivalry is about far more than just technology—it is also about design. Samsung and LG Electronics have been the world's top two applicants in design patents for many consecutive years (WIPO 2020).

Figure 6 and Figure 7 juxtapose the co-inventor networks of Samsung and LG Electronics based on three years of design patent application in Korea, where their headquarters and design centres are located. Over the three years, Samsung published 2,939 design patents with 554 inventors and LG Electronics published 2,578 design patents with 310 inventors. There is no noticeable difference in the volume of design patents. However, a glimpse of the co-inventor networks clearly shows that the size and placement of design teams are not identical.

In the co-inventor networks, each node represents one inventor and the edge connecting the nodes represents at least one co-invented design patent. Thicker edges indicate the relative strength of the connections among the inventors. Colour codes were applied to substantial clusters marked with the corresponding design categories and their Locarno Classifications: 14-04 Graphical User Interface (GUI) (in blue), 14-03 Smartphone (in green), 14-03 Television apparatus (in pink), 14-02 Wearable band and smartwatch (in pale pink), 15-07 Refrigerator (in red), 15-05 Washing machine (in emerald), and 23-04 Air conditioner (in grey).

Both companies have many design patents in Class 14 (Digital communication devices) and Class 15 (Home appliances). However, their choice of product lines and target markets is dissimilar: Samsung tends to focus on GUIs (36.61%), followed by smart equipment - smartphones and tablets (10.12%)- and LG Electronics's primary focus is upon TV sets (11.39%), followed by smartphones (5.42%), GUIs (4.65%), and air conditioners (4.34%).

Figure 8 and Figure 9 provide us with an enlarged view of Samsung and LG Electronics's respective GUI clusters and marked differences can be observed regarding their size and relative placement. Samsung shows one large, independent GUI cluster on the top of the network. Presumably, a lesson learned from the latest Apple and Samsung patent litigation affects their active patenting activities relating to GUI-related designs. In addition, Samsung have the capacity to issue somewhat centralized commands to harmonise user interface designs for various product lines. By contrast, LG Electronics forms middle- or small-sized clusters which are even further splintered into micro clusters according to the target products. For instance, there is one small GUI cluster (in blue) a bit beneath the television cluster (in pink); there is another to the left of the smartphone cluster (in green); and a third to the right of the air conditioner cluster (in grey).

To sum up, Samsung's design team is grounded in the GUI cluster and pivots around other digital device designs, whereas LG's GUI designers are afforded more opportunities to collaborate with diverse design teams, with greater levels of authority and design flexibility being granted to each business division to make changes when necessary.

Discussion and Conclusions

Intellectual capital has come to assume a more and more prominent position in the innovation activities of leading companies. Surprisingly, however, as innovation is still mostly conceptualized as "technological", design patents have not been part of the discussion on innovation.

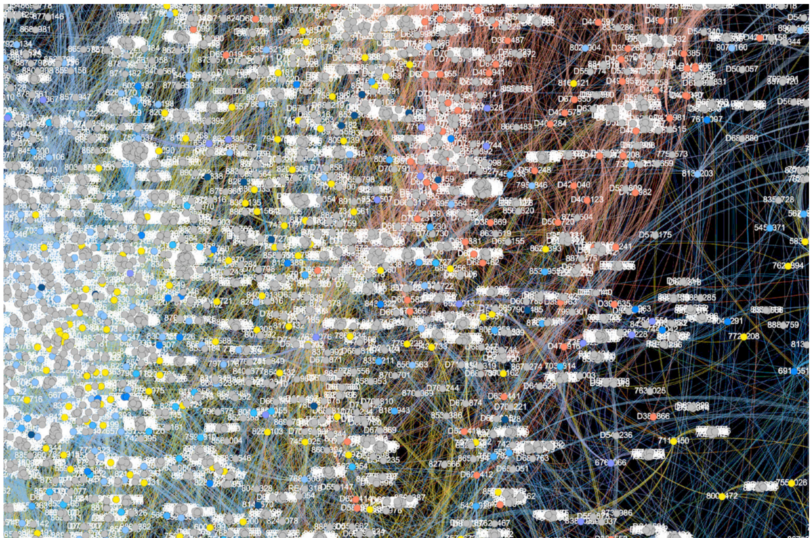
Adopting a network lens, this photo essay has made an effort to shed light on hidden patterns, trends, connections between technologies, designs, and individuals in their respective businesses. The paper has several implications for the study of how design-driven innovation occurs and may be managed (i.e., Verganti (2008)'s metamodel for the management of design-driven innovation). First, the patent citation maps of Dyson and Apple demonstrated that silo investigations of technology patents might not fully depict the details and implications of complex innovation activities. The synergistic effect of cross-pollination between design and technology patents stimulates radical innovations. For instance, Dyson's first bladeless fan design patent (US D602,143) was highly cited by subsequent design and technology patents (i.e., counts of forward citation in both design and technology). Citation-weighted patents can be further treated as indicators of radical innovation, as measures of the quantitative degree of radicalness in design-driven innovation. In this way, we can better identify how knowledge spill overs originating from design affect technological innovation.

Second, the cases of co-inventor networks in design patents at Samsung and LG disclosed the structure of their corresponding design innovation teams, revealing interesting information that would explain the design direction and strategy that each company has taken. Networks such as these can serve as visual cues to better understand how design innovation teams can be successfully managed, while monitoring the developing dynamics of competing designer networks.

Finally, Margaret Bruce and John Bessant (2002) have addressed the concern that good product design is sometimes protected by technology patents and other kinds of intellectual property rights. One should bear in mind that it is not always beneficial to invest in design innovation by looking at design patents, as the benefits may in some cases be reduced by the presence of other intellectual properties—technology patents, trademarks, or copyrights.

Acknowledgments

This work was supported by the National Research Foundation of Korea funded by the Ministry of Science and ICT, South Korea (No. NRF-2018X1A3A1070163). Jieun Kim is the corresponding author of this paper.



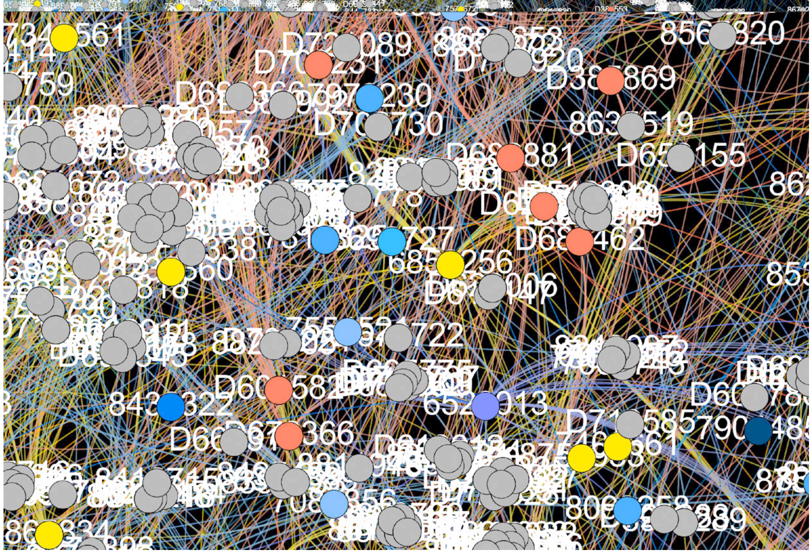


Figure 4 (previous page): Overview of Apple's patent network map (2001–2020). *Source: authors.*

Figure 5 (top): Enlarged view of Apples' patent network map. *Source: authors.*

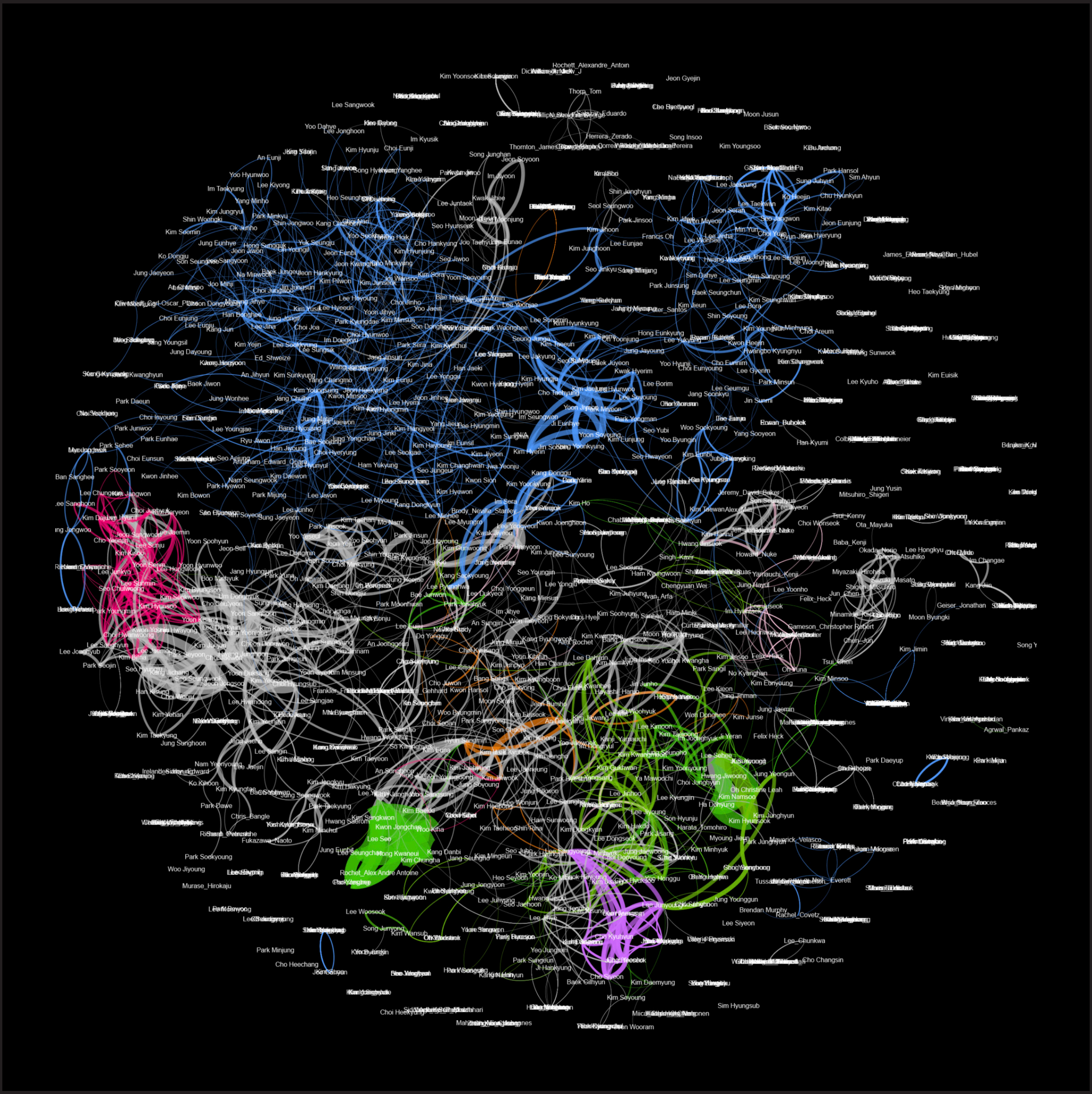


Figure 6: Samsung's co-inventor network (2014–2017).
Source: authors.

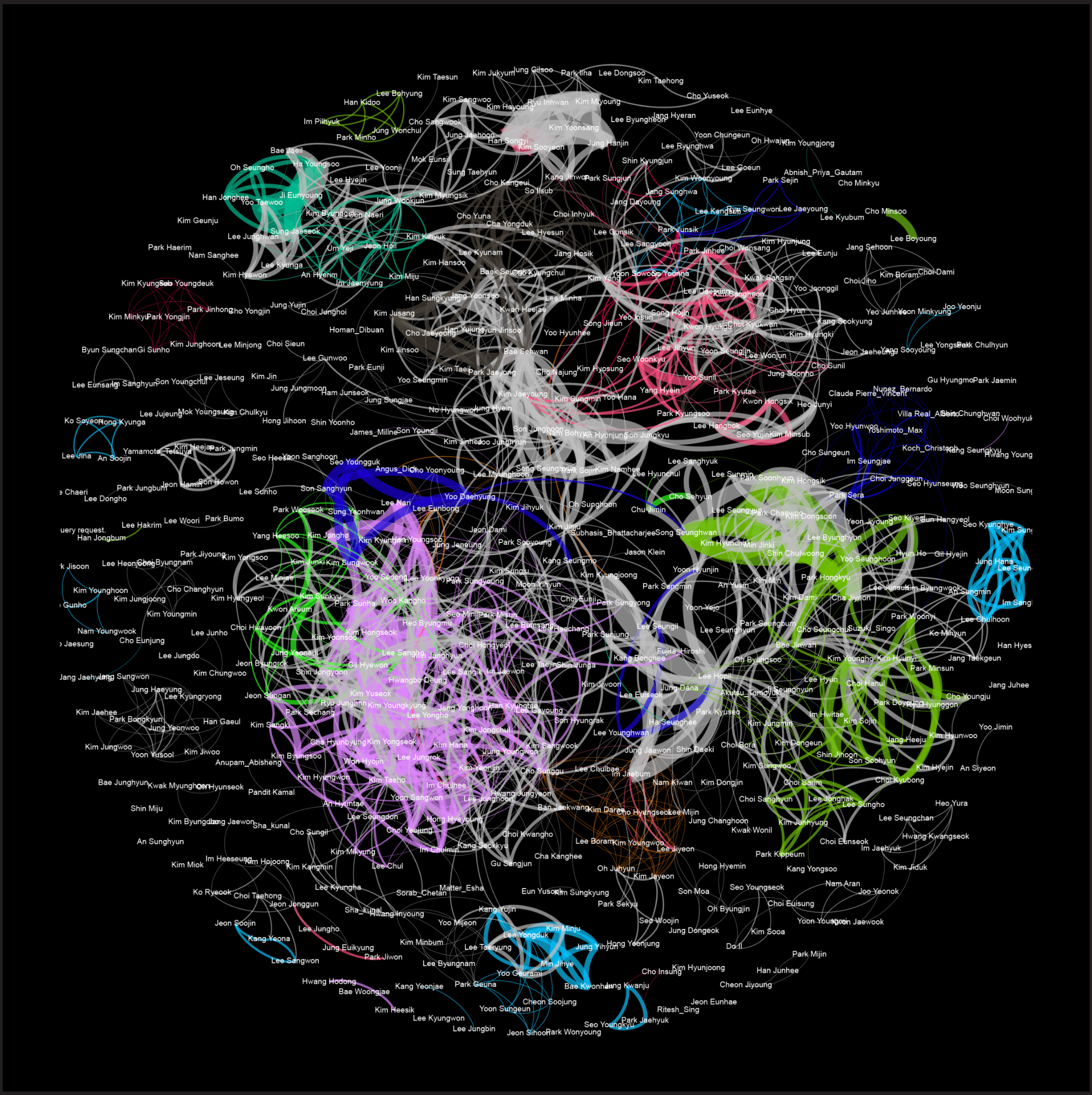


Figure 7 : LG Electronic's co-inventor network (2014–2017).

Source: authors.

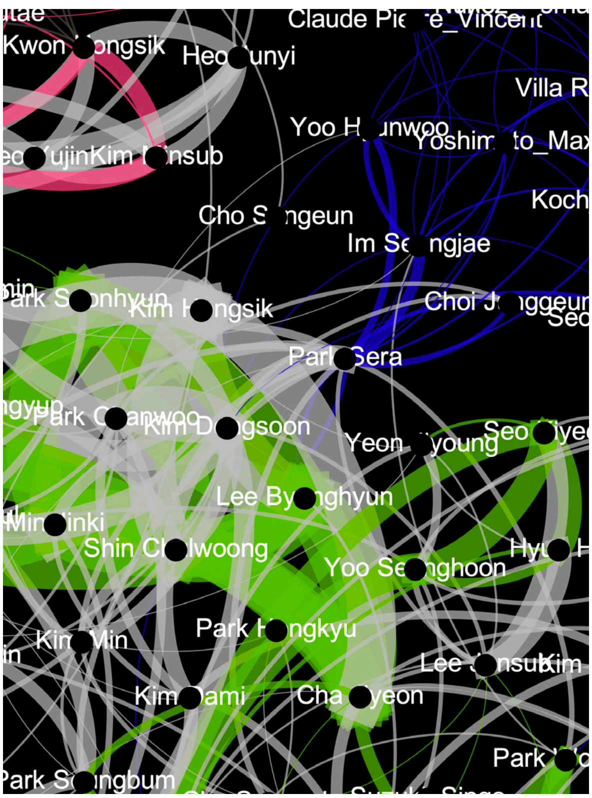


Figure 8 (top): Enlarged view of Samsung's GUI cluster. *Source: authors.*

Figure 9: Zoom-in of LG's GUI cluster. *Source: authors.*

Bibliography

Borja de Mozota, Brigitt, and Steinar, Valade-Amland. *Design: A business Case: Thinking, Leading, and Managing by Design.* New York: Business Expert Press, 2021.

Bruce, Margaret, and John R. Bessant. *Design in business: Strategic innovation through design*. Pearson education, 2002.

Filitz, Rainer, Joachim Henkel, and Bruce S. Tether. "Protecting aesthetic innovations? An exploration of the use of registered community designs." *Research Policy* 44, no. 6 (2015): 1192-1206.

Kim, Jieun, Buyong Jeong, and Daejung Kim. "Patent Analytics." *Springer Books* (2021).

Kim, Daejung, and Jieun Kim. "Is innovation design-or technology-driven? Citation as a measure of innovation pollination." *World Patent Information* 64 (2021): 102010.

Kim, Daejung, and Jieun Kim. "Measure of Design M&As: Exploratory investigations of IP analysis in design." *Strategic Design Research Journal* 12.1 (2019): 43-61.

Maeda, John. "Design in tech report." Updated March 11, 2017. https://designintech.report/2017/03/11/design-in-tech-report-2017/

Prell, Christina. *Social network analysis: History, theory and methodology*. London: Sage, 2012.

Trippe, Anthony. "Guidelines for preparing patent landscape reports." *Patent landscape reports. Geneva:* WIPO (2015): 2015.

Verganti, Robert. "Design, meanings, and radical innovation: A metamodel and a research agenda." *Journal of product innovation management*, 25, no. 5 (2008):436-456.

Yoshioka-Kobayashi, Tohru, Tsuyoshi Fujimoto, and Atsushi Akiike. "The validity of industrial design registrations and design patents as a measurement of "good" product design: A comparative empirical analysis." *World Patent Information* 53 (2018):14-23.

WIPO. *WIPO IP Facts and Figures*. Geneva: WIPO Publication, 2020.

Bio

Taek-Kyun Shin is currently a PhD student at the Graduate School of Technology and Innovation Management, Hanyang University. He has worked for IP Team in Samsung Electronics since 2010. Prior to joining the IP team, he had been a semiconductor design automation engineer for 10 years. His interests include business intelligence, deep learning or machine learning based big data management and network-based design analysis.

Jieun Kim is an associate professor at the Graduate School of Technology and Innovation Management, Hanyang University and co-directs an interdisciplinary research lab - Imagine X lab since 2013. She has a BA in Industrial Design from KAIST (2007) and an MS and PHD in Industrial Engineering from Arts et Métiers ParisTech, Paris (2008/2011), followed by the Leverhulme Research Fellowship (2012) at Royal College of Art in London. She was a visiting associate professor at Human Communication Technologies Lab, University of British Columbia (2020). She served as a general co-chair of ACM TVX 2018 and continued to contribute to many international design and innovation management communities as reviewers and speakers.

DOI: 10.31182/cubic.2023.6.58