



Realising the affective potential of patents: a new model of database interpretation for user-centred design

Andrew Wodehouse, Gokula Vasantha, Jonathan Corney, Ananda Jagadeesan & Ross MacLachlan

To cite this article: Andrew Wodehouse, Gokula Vasantha, Jonathan Corney, Ananda Jagadeesan & Ross MacLachlan (2018) Realising the affective potential of patents: a new model of database interpretation for user-centred design, *Journal of Engineering Design*, 29:8-9, 484-511, DOI: [10.1080/09544828.2018.1448056](https://doi.org/10.1080/09544828.2018.1448056)

To link to this article: <https://doi.org/10.1080/09544828.2018.1448056>



© 2018 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group



Published online: 08 Mar 2018.



Submit your article to this journal [↗](#)



Article views: 381



View Crossmark data [↗](#)



Citing articles: 1 View citing articles [↗](#)

Realising the affective potential of patents: a new model of database interpretation for user-centred design

Andrew Wodehouse, Gokula Vasantha, Jonathan Corney, Ananda Jagadeesan and Ross MacLachlan

Design Manufacture and Engineering Management, University of Strathclyde, Glasgow, United Kingdom of Great Britain and Northern Ireland

ABSTRACT

This research sets out a new interpretation of the patent database using affective design parameters. While this resource contains a vast quantity of technical information, its extraction and use in practical design settings is extremely challenging. Until now, all filing and subsequent landscaping or profiling of patents has been based on their technical characteristics. We set out an alternative approach that utilises crowdsourcing to first summarise patents and then applies text analysis tools to assess the summarising text in relation to three affective parameters: appearance, ease of use, and semantics. The results been used to create novel patent clusters that provide an alternative perspective on relevant technical data, and support user-centric engineering design. The workflow and tasks to effectively interface with the crowd are outlined, and the process for harvesting and processing responses using a combination of manual and computational analysis is reviewed. The process creates sets of descriptive words for each patent which differ significantly from those created using only functional requirements, and support a new paradigm for the use of big data in engineering design – one that utilises desirable affective qualities as the basis for scouring and presenting relevant functional patent information for concept generation and development.

ARTICLE HISTORY



Received 30 September 2017
Accepted 27 February 2018

KEYWORDS

Patents; crowdsourcing;
affective design

Introduction

Patents are recognised as a critical part of the innovation economy, providing legal protection with respect to intellectual property. If ‘big data’ is an identifier for large-scale, complex data sets that require new means of interpretation in order to extract business impacts (Boyd and Crawford 2012; McAfee and Brynjolfsson 2012), then the patent database is a particularly challenging form. A world-wide data set that is constantly expanding, each document contains a significant degree of pictorial and linguistic content describing a large variety of subject matter. With more than 64 million online patent records instantly available, and the global growth in patent applications at 7.8% (World

CONTACT Andrew Wodehouse  andrew.wodehouse@strath.ac.uk  Design Manufacture and Engineering Management, University of Strathclyde, James Weir Building, 75 Montrose Street, Glasgow G11XJ, United Kingdom of Great Britain and Northern Ireland

Intellectual Property Organization 2016), simply navigating these effectively has become increasingly difficult. Landscaping software such as Derwent Innovation's ThemeScape (www.thomsoninnovation.com) has sought to harness the information for the purposes of strategy formation and technological horizon scanning. However, grouping and presentation is based exclusively on the technical characteristics of the patents, and relies heavily on the patent classifications used in their assignation. Bubela et al. (2013) argued that a lack of transparency and inconsistency persists in current landscaping practices. Similarly, Yoon, Park, and Kim (2013) suggest that the patent network may be ambiguous or meaningless if the structural relationship among patents is unclear. Commercially available patent landscaping software programmes are expensive, and while this can provide support for strategic and high-level innovation strategies (Brown 2009), they are less useful in terms of practical engineering design work – generating solutions for the design of products, systems and services – as it requires users to interrogate each technological cluster and review each patent in detail. This is time consuming and inefficient given the level of technical detail and stylised language and presentation used in patent documents. Using a procedural approach provides a more structured and efficient means to interact with the database, the best known example being TRIZ ('the theory of inventive problem solving') which distils key functional requirements from the patent database in order to provide a problem-solving methodology in concept generation activity (Altshuller, Altov, and Shulyak 1994). This does, however, rely on functional characteristics and presents only principles rather than tangible examples of design to users of the protocol.

This work is unique in considering how the 'big data' of the patent database may be interrogated from the perspective of engineering design implementation, and by focussing on the key implications for users – the affective potential of patents. By considering ease of use, attractiveness, and semantics we seek to look beyond the normal functional description of patents. While such a qualitative approach is not relevant to every sector (for example pharmaceuticals) and not every patent has a tangible interaction with the end user (for example an engine intake manifold), the context of this work is engineering design and its purpose is to effectively stimulate innovative design thinking. Drawing on even a proportion of the database that is used in the design and development of products, systems and services with an element of user interaction has enormous potential as a source of affective design information and to provide a new perspective on this resource.

Given the scale of the patent database and volume of information contained within it, crowdsourcing has been identified as an effective way to assess large numbers of patents. As well as being cost-effective and scalable, this has an additional advantage with respect to the qualitative nature of affective design parameters: the crowd workers, unlike patent clustering algorithms based on keyword search or, say, IPC classification codes, are able to draw on human insight, experience and imagination when interpreting patents and their possible effect on the user. In this research we provide a new workflow for extracting and presenting these parameters for designers, and build on the authors' previous research examining the feasibility of crowdsourcing for patent interrogation (Wodehouse et al., 2017).

Affective design

Even in the development of the most technologically advanced contexts, it is accepted that the user requirements must remain at the forefront if they are to be effective; it

is no longer adequate in competitive marketplaces and with discerning users to simply fulfil functional requirements such as basic performance and safety, or to achieve technical excellence in the manufacturing process. The concept of user-centred design has been critical in shifting focus towards human needs in the design and development process. This has its origins in the field of ergonomics, which seeks to ensure that human dimensions are considered in the configuration of designs, and that the resulting products are appropriate and comfortable to use. Broader user-based issues, however, require consideration of factors such as emotional reaction, narrative of experience, and cultural interpretation. Research in this area has matured in the last 20 years (Lewis 2014) and now encompasses fields including human-centred design (Maguire 2001), emotional design (Chapman 2005; Norman 2004), user experience design (Kuniavsky 2003), inclusive design (Clarkson et al. 2003), haptics (Hara 2007) and interaction design (Moggridge 2007).

Affective design is another strand of development in this vein. The affective domain (Kratwohl, Bloom, and Masia 1973) includes the manner in which we deal with things emotionally, such as feelings, values, appreciation, enthusiasms, motivations, and attitudes. We consider 'internalization' as a useful concept in understanding the nature and impact of affective design. It refers to the process whereby a person's affect toward an object passes from a general awareness level to a point where the affect is processed and consistently guides or controls the person's behaviour (Seels and Glasgow 1990). Affective aspects of physical artefacts include characteristics such as texture, form, colour, and style. These exterior characteristics are interpreted by users in an interplay of psychology, physical interaction and cultural factors that ultimately cause an emotional reaction. It is the aim of affective design to be cognisant of these in the delivery of satisfying, engaging and meaningful user experiences. The possibility of associating functional information (i.e. patents) with their potential impact on the user (affective design parameters) for a given design context is potentially a powerful way to increase visibility of these 'softer' elements of design, particularly in more technical or detailed embodiment-related activities.

In terms of measuring or quantifying these subjective elements for use in an engineering setting, Kansei Engineering is an important concept. Its aim is to optimise products or services by translating the user's feelings and needs into technical specifications. Its potential to support decision making in the development of affective products is highlighted by Barnes and Lillford (2009): they take the principles of Kansei and integrated it within a framework that links the output to product parameters for incorporation in the design process. In extracting the emotional meaning, or 'kansei' of a product, Nagasawa (2004) asserts that it cannot be measured directly – it is the causes and consequences of the process of perception that are observed. This can encompass physiological and behavioural responses, as suggested by Lokman and Nagamachi (2009) in Figure 1. Recently, several researchers have explored the adoption of scales and measures that can be used to relate affective sensory responses to physical product properties (Camargo and Henson 2015; Özcan, Cupchik, and Schifferstein 2017). However, a more established behavioural approach is one where people are asked to express emotion in words upon seeing products (Jiao, Zhang, and Helander 2006; Lee, Harada, and Stappers 2002; Yanagisawa 2011) and, depending on the format and presentation, allows the targeting of a large, diverse population through remote communication.

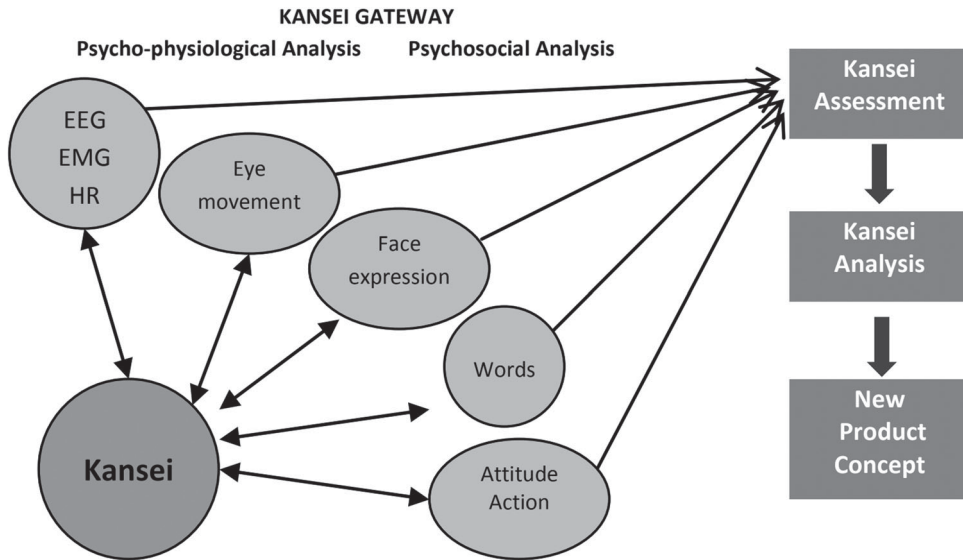


Figure 1. Different means of assessing Kansei in participants (Lokman and Nagamachi 2009).

Patents as a source of design information

As a publicly available, enormous source of data that includes descriptions of many novel, feasible, useful and non-obvious inventions (Intellectual Property Office 2015), patents have attracted a great deal of attention from researchers attempting to use them to identify patterns of innovation and technological trends. While much academic research has been in the realm of economics, engineering design is well-placed to utilise patent information given the fact that many contain novel design solutions. In theory, they are a freely available resource that can be used by designers to: review solutions to comparable technical problems; draw inspiration for new areas of research; identify trends and development in the field; examine competitors and their activity; acquire technologies to license or use freely; and avoid unintentional duplication of research. However, they have most often become a checkpoint in the design process rather than a resource to be utilised in support of design activity.

This is partly attributable to size and complexity of database. 2.9 million patents were filed in 2015, representing 6 years of consecutive growth (World Intellectual Property Organization 2016). And while freely available portals such as Patentscope (www.patentscope.wipo.int) provide instant access to the patent database, efficiently navigating this resource for design inspiration is challenging.

Another major barrier in terms of usability of the database is that the language and presentation of patents has evolved to suit the legislative and bureaucratic requirements of the system – they are not engaging documents written and presented in a way that is useful to a designer. The abstract and main image are the most accessible for interpretation, but the pertinent inventive detail is often difficult to grasp from these abbreviations. There is a lot of variation in writing style but it is often impenetrable to the average reader. Finally, the aim of the patent system – to encourage innovation by providing a period of protection for

a fixed length of time and thereafter sharing the information across society for its greater benefit – has been hijacked by companies utilising patents purely for commercial purposes. Practices such as ‘thicketing’ (deliberately stifling innovation in an area by filing a series of blocking patents) and ‘trolling’ (attempting to enforce rights against infringers beyond a patent’s value or contribution) have distorted the innovation economy to the point where they have become synonymous with the widely reported ‘patent wars’ (Moser 2013). In essence, translating patent documents into practical design ideas or requirements is not easy.

The functional nature of patents and how they are classified in the International Patent Classification (IPC) system, and other indexes, can also be challenging for non-filed experts. However, a great deal of patents in the context of engineering design relate to products, systems or services where, with some interpretation and consideration, the potential impact on the user can be identified or extrapolated. These may be fairly specific patents that reside within a product genus or type that we are familiar with. For example, the fundamental concept of an umbrella is not novel and therefore is not patentable. However, the new materials applications, opening mechanisms, handle designs and so on can be patented as long as they have a functional effect. In scrutinising these, we can infer what kind of impact the new functionality may have on the end user: for example, better weather-proofing, faster opening, or a more comfortable handle. Going one step further and linking these changes to performance, we can anticipate how it may make the user feel: more secure, that they will not get wet, more blasé that the umbrella can be opened in an instant, or more confident about walking long distances when holding it. These are important affective parameters that drive design. If we want to take a user-centred design to develop a ‘better brolly’ then being able to look at these characteristics and work back to the kinds of function and mechanical properties that typically deliver these, we can help inform and inspire more effective affective design.

Crowdsourcing as a tool for information extraction

We have identified crowdsourcing as an economic, scalable way of collating and applying appropriate taxonomic information that could reclaim the patent database as a source of design inspiration. The term crowdsourcing was coined by Jeff Howe in 2006 as ‘the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call’ (Howe 2006). Key components in crowdsourcing workflows are repetition (i.e. multiple, parallel tasks to generate sets of ‘answers’), peer review and merger, iteration, and the linkage of payment to quality assessments.

In assessing the viability of its use in the design context, the key question is whether crowdsourcing offers any benefits when compared with other approaches. In previous studies, we have focussed on the use of the crowd in patent clustering as this is an aspect of analysis where the need for insight and interpretation has proven challenging for computational approaches (Wodehouse et al. 2017). In performing comparative analyses of the crowd with computer algorithms and commercial landscaping software, it was found not only to be economically viable, but that the crowd was able to identify more linkages between patents, with greater rationale.

Method

In this work, we take a word-driven approach similar to the collection of Kansei terminology, where users are asked to express their response in words upon seeing products (Nagamachi 1995). Rather than assessing a finished product, we expected the crowd to interpret how patents could be applied and used. In their work on the capture of users' perception of experience and meaning in an information technology setting, Nurkka, Kujala, and Kempainen (2009) advocate the use of 'projective' techniques. We have adopted this technique by asking the crowd to describe how patents could affect users in their implementation, rather than distributing a questionnaire or survey that outlines responsive options and asking them to select one or more. Drawing on the projective categories outlined by Hoyer and MacInnis (2007), we have asked them to *associate* (connect the patent with use) and *construct* (interpret user response). We have identified three key characteristics of patents to be considered in relation to affective design: visual attractiveness, ease of use and semantics. These outline three phases of experience in terms of initial visual interrogation, physical or cognitive interaction, and critical reflection. These three phases of experience can be broadly equated to Norman's (2004) *visceral*, *behavioural*, and *reflective* levels of design in the sense that they deal with the initial visual interrogation, followed by physical interaction, and finally reflection on the experience of using an artefact:

- *visual attractiveness* in what sense is this patent visible to the user and how might it be made visually appealing in context?
- *ease of use* to what degree does the user interact with this patent and how can it be made as comfortable/convenient as possible?
- *semantics* what cultural, social, personal or emotional meanings and/or issues might arise as a result of this innovation?

Patent data set

This work is focussed on patent clustering and knowledge extraction, rather than searching for the most relevant patents. There are well established techniques using either meta-data (inventors, citations, classification etc.) or patent text searches that can provide broad sets to work with (Hitchcock 2005; Montecchi, Russo, and Liu 2013; Ryley, Saffer, and Gibbs 2008). We have therefore selected an existing set of 60 patents in the area of electronic book readers to work with. This provided a diverse but manageable source in a consumer-related product sector – ideal for testing the viability of generating affective parameters using the crowdsourcing approach. Samples in this data set are used recently in the exploration of a 'design-for-patentability' process model (Kokshagina, Le Masson, and Weil 2016; Le Masson et al. 2017), and an advantage of reusing this data source is the opportunity for contrasting different approaches to their interrogation and use. Appendix 1 lists all the chosen patents along with patent number and title. The collection of patents was from across different patent systems (i.e. from United States, China, Europe, Japan, Korea and World Intellectual Property Organization). These 60 patents cover a wide range of topics in the electronic book domain: support for reading, bookmarking, page turning and transition (i.e. browsing), multi-touch interaction, haptic/tactile feedback etc. This diversity of topics was helpful in exposing our analysis to a full range of affective parameters, and to provide a

basis for understanding the distinct characteristics of the patent clusters that subsequently emerged.

Crowdsourcing procedure

We used CrowdFlower (www.crowdflower.com), a commercial crowdsourcing platform, to gather crowd responses in the process of extracting affective parameters in conjunction with Microsoft Excel for the documentation and management of tasks and responses. CrowdFlower provided an adaptable interface that allowed for all 60 patents to be issued at once. The crowdsourcing process is illustrated in Figure 2, and describes the stages of task *preparation*, *design*, *distribution* and *analysis*. Crowdsourcing results are significantly

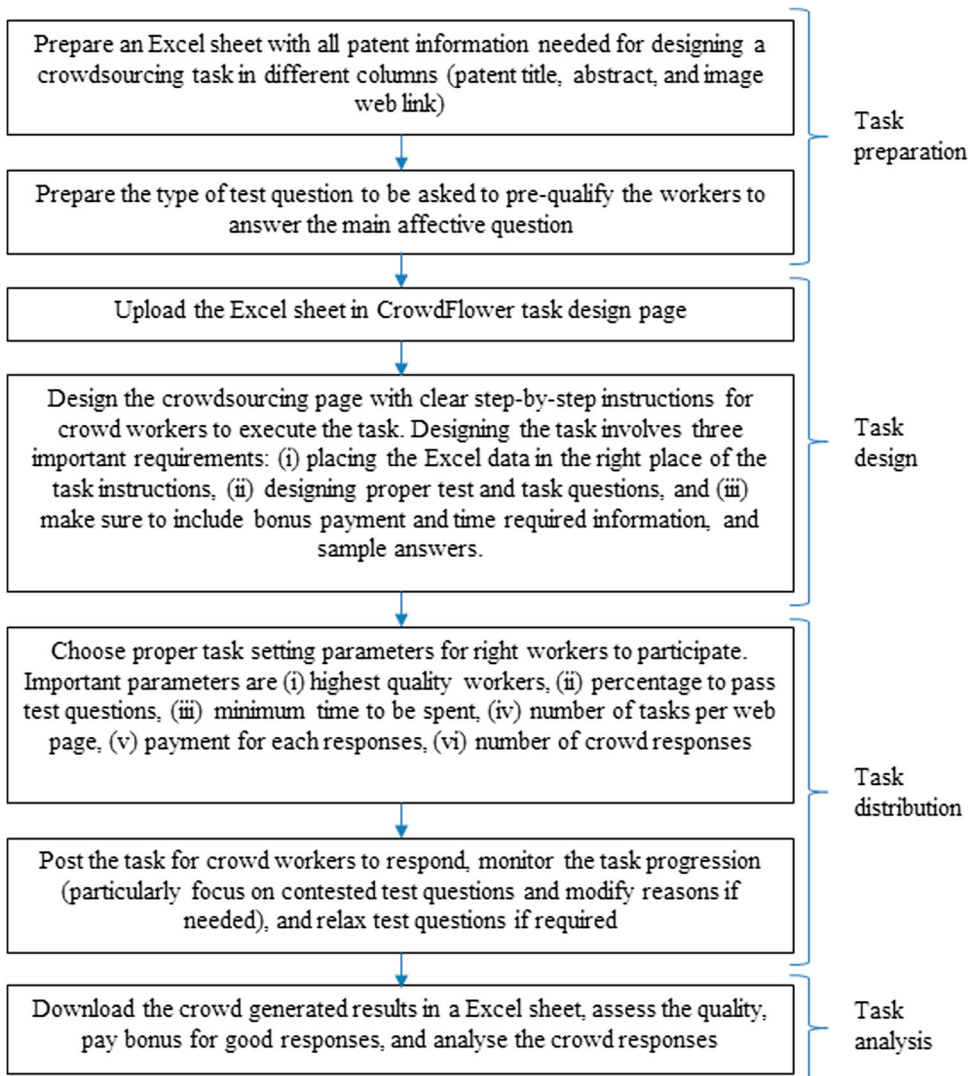


Figure 2. Process to develop the affective crowdsourcing task.

improved with the inclusion of test questions to act as a screen for potential workers, and in this study this was achieved via the inclusion of a Function, Behaviour, Structure (FBS) classification task based on patent title information. The effectiveness of this screening process was demonstrated in Vasantha et al. (2016). This was useful in establishing that the workers were comfortable with technical information and capable of making appropriate interpretations based on what they reviewed. To make it clear for crowd workers, FBS was represented as *what the patent does, how the patent works, and what the patent was made up of* respectively.

Describe "Visual Attractiveness" Of A Given Patent

Instructions ▾

Please read the given patent information

Patent Title: SYNCHRONIZING MULTIPLE READING POSITIONS IN ELECTRONIC BOOKS

Patent Description: An electronic book system is configured to allow a user to read a primary portion of an electronic book, then switch to reading a secondary portion of the book, the secondary portion being presented based on a current reading position for the main portion. A reader can repeatedly switch back and forth between primary and secondary portions without losing track of the reader's progress through the book. As an example, a reader in a textbook can immediately switch to a problem set corresponding to the reader's current position in the textbook.

Patent Picture:

Choose the category based on the title information: (Quiz question) (required)

- The title explains what the patent does
- The title explains how the patent works
- The title explains what the patent made up of
- The title explains what the patent does and made up of
- The title explains how the patent works and made up of
- The title explains what the patent does and how it works

Describe "visual attractiveness" of the given patent: Explain visual attractiveness of various functionality of the given patent. Your answer should detail what features have strong visual attractiveness, and explain why. Think about various 'visual attractiveness' characteristics such as elegance, simplicity, robustness, organic, functional, colourful, etc. You can also say about the functionality that is not relevant for visual attractiveness (and why) if that is appropriate. (Your answer should have minimum 25 words.) (required)

Give suggestions for how can the patent be visibly attractive to the user: Explain what features need to be improved for visual attractiveness. (Your answer should have minimum 25 words.) (required)

Patent title, abstract and image allow worker to understand patent functionality

Text question to ensure worker has ability to interpret patent content

Text box to complete description of visual attractiveness (minimum 25 words)

Text box to complete suggestions for improvement to visual attractiveness (minimum 25 words)

Figure 3. Sample crowdsourcing task page for visual attractiveness parameter.

Table 1. Example of a worker response for semantic parameter in relation to a single patent.

Patent	Semantic interpretation of patent	Extracted adjectives	Extracted functional key phrases
WO201-080258: Virtual page turn	This patent has a really valuable functionality and that is to try and emulate the experience of reading physical books. Many people that are not used to technology and prefer physical books will feel more comfortable using this type of function as it will make them feel like they're reading physical books. For users that are already accustomed to eBook applications and devices, this function may seem unimportant and time-consuming, but it would depend on whether it's important for them or not to emulate the reading experience related to physical books.	valuable, comfortable, important, physical, unimportant, many, time-consuming,	reading physical books, prefer physical books, reading experience, ebook applications, time

The interface presented to the crowd workers for the visual attractiveness parameter is illustrated in Figure 3. It presents the patent title, abstract and main image for the worker to understand the basic context and features of the invention. Below this, the FBS-based pilot question is presented as a multiple choice 'quiz'. The worker is then invited to describe visual attractiveness, with explanation of the term and examples of response to assist the worker in providing appropriate answers and rationale. This can include a response indicating that visual attractiveness is not relevant to this patent, but requires that rationale is provided. There is then a dialogue box which invites workers to suggest improvements or changes that could be made to improve the patent's affective quality. The format and presentation for the visual attractiveness and ease of use parameters were identical. Given its focus on context, for the semantic qualities workers were asked only to interpret the innovation with respect to the potential cultural, social, personal or emotional meanings.

An example of a worker response in relation to the semantic parameter is shown in Table 1. In addressing a patent on virtual page turning, it provides a semantic interpretation of the technology and in particular addresses the issue of to what extent it should reference and mimic the familiar physical interaction. Since the adjectives rely on textual analysis, they broadly reflect the primary concerns while lacking internal logic – for example both important and unimportant are listed. The principle of crowdsourcing dictates that repetition of the task across a sufficiently large number of workers will result in the appropriate adjectives emerging through aggregation. For the extracted functional key phrases, the important aspects of embodiment are described, including references to physicality and time. Again, through consolidation of multiple responses, functional phrases that aid understanding of patent intent and application more readily than a technical abstract begin to emerge. The extraction of both adjectives and functional key phrases is addressed in more detail in the Analysis section below.

Results – crowd participation and task completion

This section reviews the statistics of the crowd's initial response, level of participation and success in task completion. Assessing the depth and quality of results was essential since



Figure 4. Crowd participants' location map (generated using BatchGeo, <https://batchgeo.com>).

Table 2. Summary of crowd responses for the three affective parameters.

	Total responses	Unique workers	Workers rejected based on test questions	Test question checking ceased (hours)	Task completion time (hours)	Accepted responses (%)	Cost incurred per response (\$)
Attractiveness	296	34	3	74	84	82%	0.10
Ease of use	205	21	9	26	38	73%	0.20
Semantics	472	56	17	–	120	86%	0.09
Total	973	111	29	–	242	–	0.12

they were to be utilised for the affective clustering analysis. In total, 88 different workers participated in three tasks. Figure 4 shows the location of participants, and highlights the global reach of crowdsourcing platforms. While we were unable to track personal information on our platform, a recent demographic survey shows that the crowd population is becoming increasingly international with an equal gender distribution, average age of 32 years, and almost half having graduate education (Ipeirotis 2010; Ross et al. 2010).

For each of the three semantic parameters, Table 2 sets out task completion information in relation to the crowd description – the responses for suggested improvements were not used as part of the analysis. The total number of responses was significantly higher than the number of tasks successfully completed, which is reflective of the initial 'swarm' of crowdworkers that tend to congregate on any new task posted to the platform. As noted above, test questions are essential to filter out unsuitable workers, particularly during this initial phase of posting. The number of workers rejected based on unsuccessful completion of the test questions (two out of three correct answers was deemed acceptable) is shown, but the principal role of the test questions is to deter workers seeking tasks that can be completed quickly and mechanically. The task completion time shows how long the task was available on the platform to secure the responses for each parameter. We have additionally noted the time after which test questions were no longer checked: this tactic was employed after the initial crowd surge had abated to try and maximise the volume and speed of responses. It did not materially affect the data used for analysis, as all responses were evaluated for quality before being incorporated into our analysis whether test questions were assessed or not. It does however highlight the trade-off between the percentage of accepted responses and task completion time: across the three tasks,

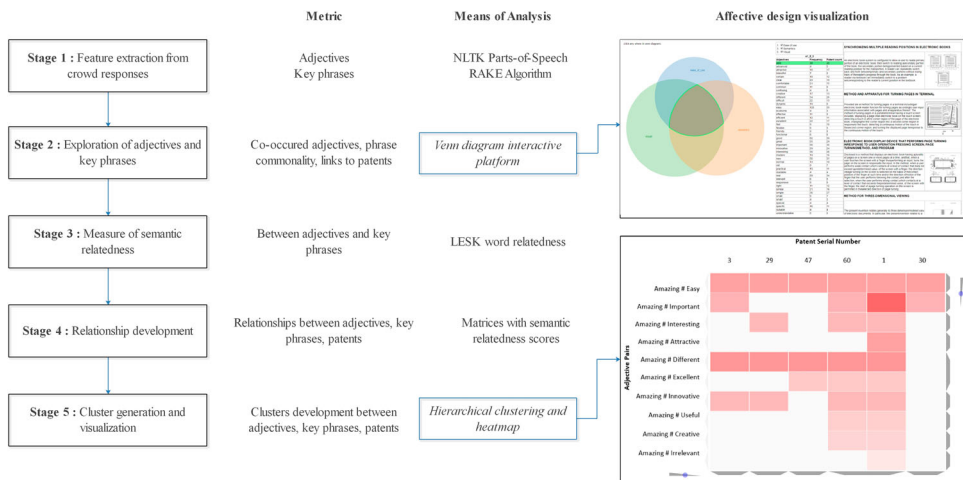


Figure 5. Stages of analysis for affective patent clustering, with metrics, means of analysis and use for effective design.

the percentage of accepted responses was 13% higher for the 82 h when test questions were in place. Overall, however, the percentage of accepted responses across the three tasks was healthy, with 73% for the ease of use task the lowest. In terms of economic outlay, the total exercise cost \$114.12 with the average cost per response calculated at 12 cents.

Analysis – navigation of patents via affective clustering

Using the results gathered from the crowd, a systematic process for the affective clustering of the patent set was followed, as set out in Figure 5. This illustrates the five main stages of analysis, as well as the metrics and means of analysis used at each stage. Stages 2 (Exploration of adjectives and key phrases) and 5 (Cluster generation and visualisation) have resulted in interfaces useable by designers to support concept generation and development. The stages are discussed in detail below.

The first stage of the process was to extract core features from the crowd's responses, i.e. adjectives and functional key phrases. Responses that were either directly copied from the patent abstract or improper sentences were rejected and those deemed acceptable were cleaned for spelling mistakes and in certain cases translated. The rejected adjectives were words that did not describe the affective nature of the patent features (e.g. words such as primary, secondary, physical, digital, etc.). And while tasks were set in English, there were 38 instances where workers responded in different languages. Table 3 tabulates the number of adjectives generated and percentage of adjectives accepted for further analysis for the three crowdsourced tasks. The Parts-of-Speech (POS) tagger from the Python Natural Language Toolkit (NLTK) was used to collect all adjectives and the frequency of their use (Loper and Bird 2002). The Rapid Automatic Keyword Extraction (RAKE) approach was then used to extract functional key phrases (Rose et al. 2010). RAKE is a domain- and language-independent method that extracts significant phrases from text contents using stop words and phrase delimiters to partition the text content into candidate keywords. It was deemed

Table 3. Summary of adjectives extracted from the responses for the three affective parameters.

	Number of adjectives extracted by NLTK POS		Percentage of accepted adjectives	
	Description	Suggestion	Description	Suggestion
Visual attractiveness	228	227	78%	76%
Ease of use	213	173	50%	65%
Semantics	324		77%	

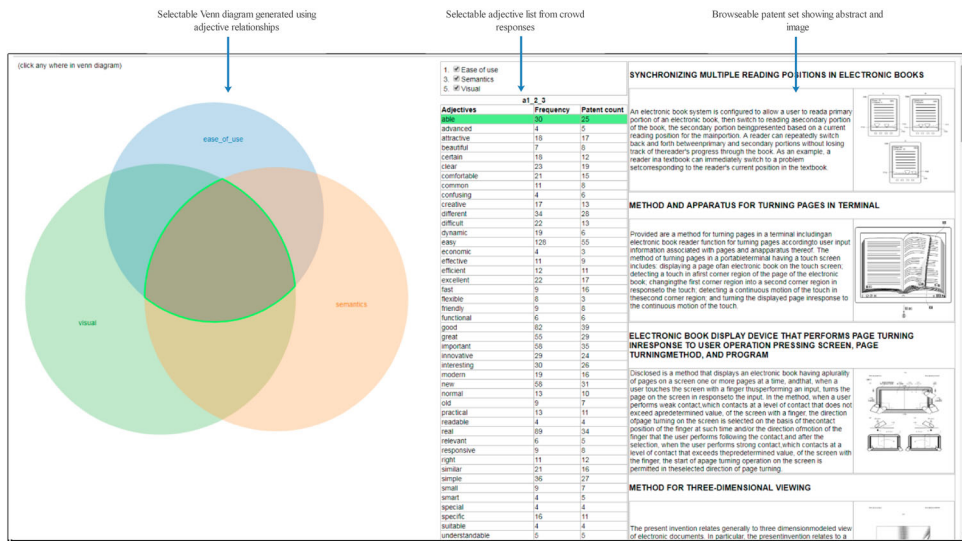


Figure 6. Venn diagram to explore adjectives associated with affective parameters.

appropriate because word associations are measured by automatically adapting to the style and content of the crowd’s responses.

The second stage provides an opportunity for designers to explore adjectives generated in the crowd’s responses concerning the three affective parameters through interactive web-based Venn diagrams. The interface (Figure 6) was constructed using a combination of a MySQL database and the Javascript package Venn.js (<http://www.benfrederickson.com/venn-diagrams-with-d3.js>). It facilitates the exploration of frequent, common and unique adjectives and key phrases by displaying the patent set, adjective list and resulting Venn diagram visualisation side-by-side. This allows the designer to click the area of interest in the Venn diagram to select associated adjectives and related patents for that particular region. In total, 596 unique adjectives were identified from the crowd’s responses for all three affective parameters. Reoccurring adjectives in the crowd’s responses can be explored by choosing multiple adjectives from the list, and with the associated adjectives listed along with frequency and patent counts for that selected region, the designer can also choose to start with an interesting adjective from the list to determine associated patents and inspect the relevant technical information from the abstract and image.

The third and fourth stages generate information necessary for creating clusters between adjectives, functional key phrases and patents among the three affective parameters. Semantic relatedness between adjectives, key phrases and adjectives-key phrases

were calculated using the LESH approach (Lesk 1986). This finds the relatedness of two words by identifying the extent of overlap of their dictionary definitions – adapted here to use WordNet definitions (Banerjee and Pedersen 2002; Pedersen, Patwardhan, and Michelizzi 2004). The generated semantic relatedness scores are mapped to develop matrices between adjective pairs and patents, and key phrase pairs and patents for all three affective parameters. The matrices contain the full LESH score only if both adjectives in a pair was found in crowd responses to a particular patent, and halved if only one adjective was found.

The fifth and final stage involves generating and visualising clusters. The matrices generated in the previous stage formed the input data for generating hierarchically clustered interactive heatmaps with Clustergrammer (<http://amp.pharm.mssm.edu/clustergrammer>). Different clusters can be explored by through functional descriptions, affective descriptions, and how they are linked for the three affective parameters. The principles for doing so are set out below in relation to one of them: the *ease of use* parameter.

Cluster generation using functional descriptions

Functional key phrases from crowd responses were extracted using the RAKE algorithm (Rose et al. 2010). The semantic relatedness LESH scores were calculated for each extracted and filtered functional key phrase pairs. Hierarchical clusters were generated using Clustergrammer by structuring the generated scores in a matrix form between key phrase pair and patents in which the particular key phrase pairs found. The score for a patent was established based on the number of word matches occurred between key phrase pair and crowd responses for that patent. Figure 7 illustrates a cropped sample of clusters generated between *haptic feedback* in comparison to other functional key phrases and patents for the *ease of use* parameter (the complete heatmap can be viewed using the caption link). The following information can be explored by the designer:

- *Functional pairs and patents.* The colour variations show that the functional key phrases '*existing material easily, system makes decisions, intuitive paper book*' have the stronger relationship with *haptic feedback*. Patent 19 has presence of many key phrase pairs compared to other patents.
- *Functional pair and patent clusters.* All the subset functional key phrases shown in Figure 8 are clustered as a single group (as demonstrated in the vertical trapezoidal area). However, patents are clustered into two groups: (7, 12, 26) and (2, 19, 37). The characteristics of clustered patent groups are studied subsequently in relation to functional key phrases.
- *Functional patent relationships.* The patent cluster (7, 12, 26) is sparse considering there is no key phrase pair common among all the three patents. Whereas, the *easy access* key phrase is common among the patent cluster (2, 19, 37). Comparing this cluster (2, 19, 37) with the functional cluster listed in Appendix 2 shows that *turning page* and *gesture* functional elements are common between these patents. However, the common functional key phrases emerging among these patents are not identified in the functional clusters. Also, there are no common IPC classification codes between the patents in this cluster (Appendix 3). Thus, creating these functional key phrase clusters from the crowd responses produces possible functional relationships that are not identified by conventional review or classification.

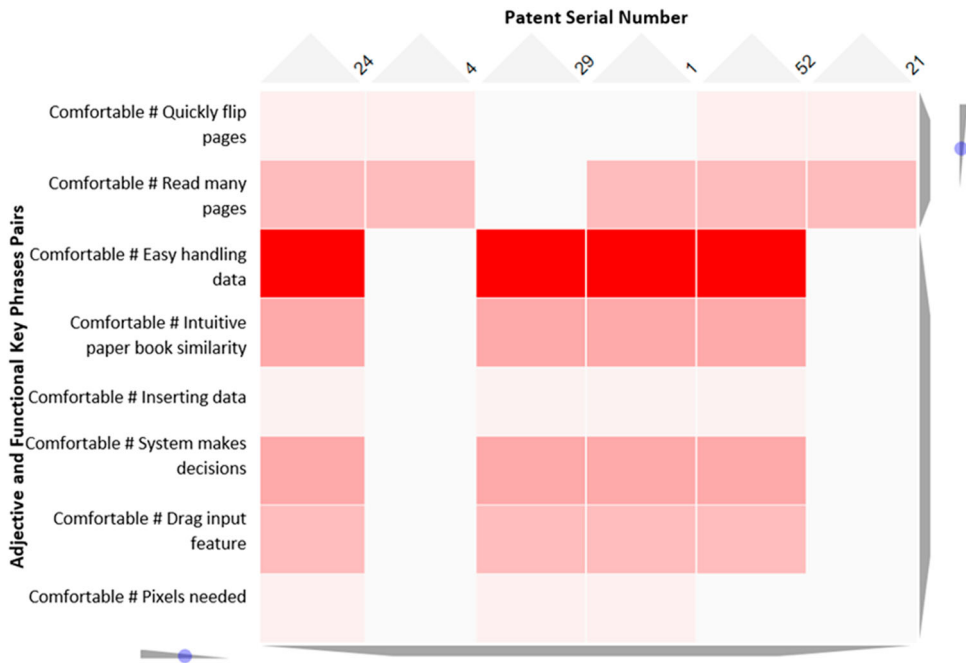


Figure 7. Clusters based on functional key phrases (please refer to http://amp.pharm.mssm.edu/clustergrammer/viz_sim_mats/59cd072dc1595237b1e4f7c9/Copy%2520of%2520ease_of_use_pos_keyphrase_score_matrix_haptic.txt for full *haptic feedback* functional key phrase heatmap).

Cluster generation using affective descriptions

Figure 8 illustrates a cropped sample of adjective pairs with focus on the *comfortable* adjective and patents within the *ease of use* parameter (the complete heatmap can be viewed using the caption link). The rows and columns have been hierarchically clustered using cosine distance and average linkage. The advantages of this approach to visualisation are that it is interactive (zoomable, reorderable, filterable), and that it can dynamically produce visualisations based on the designer's adjective selection. The designer can therefore readily explore the following information:

- *Adjective pairs and patents.* This is illustrated through colour variations: the stronger relationship has the darkest colour, and colour lightens for the lower LESK scores. In this case, the heatmap illustrates that the strongest score is established between the *comfortable* and *easy* adjectives.
- *Adjective pair and patent clusters.* The trapezoidal area at the vertical and horizontal ends illustrate these clusters. For example, the *comfortable*, *easy* and *intuitive* adjectives are grouped together based on the crowd responses and the LESK scores. In a similar way, clusters between patents can be explored.
- *Affective patent relationships.* In this cropped cluster, patents 4 and 60 have many common relationships with adjective pairs, illustrated by the similar colour shading in their respective columns. However, no function link was found as part of the expert manual review of the patent set conducted by one of the researchers (Appendix 2) and there is

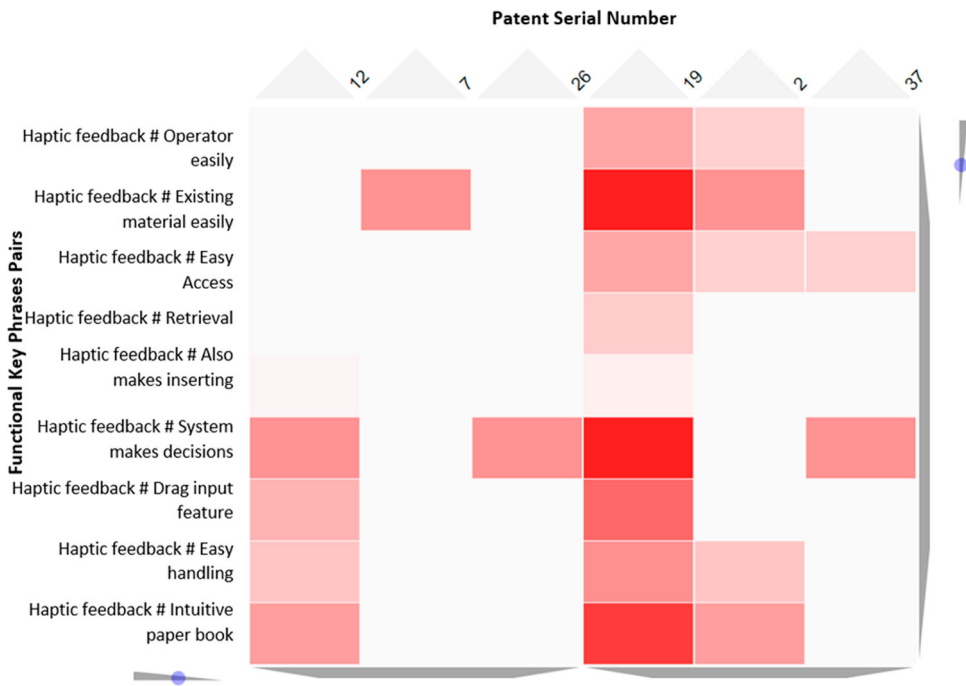


Figure 8. Clusters based on adjectives and patents within *ease of use* parameter (please refer to http://amp.pharm.mssm.edu/clustergrammer/viz_sim_mats/59ce532ec1595237b1e4fb7c/Copy%2520of%2520ease_of_use_pos_adj_score_matrix_comfortable.txt for full *comfortable* adjective heatmap).

no common IPC classification code between them (Appendix 3). Thus, the affective similarities between patents can help identify functional relationships that are, again, not revealed through conventional review or classification.

Cluster generation using affective and functional descriptions

The semantic relatedness LESK scores were calculated between each adjective and functional key phrase pair. These generated scores were mapped to respective patents with reference to crowd responses to generate a keyphrase#adjective vs patent matrix. The generated matrix was input to Clustergrammer software to find hierarchically cluster between these two parameters. Figure 9 illustrates a cropped sample of the clustering generated by the *comfortable* adjective and functional description against patents for the ease of use parameter (the complete heatmap can be viewed using the caption link). The designer can extract the following information from the generated clusters:

- *Affective/functional pairs and patents.* The colour variations in Figure 9 demonstrate that the strongest relationship is established between the *Comfortable#Easy handling* data pair and patents 1, 24, 29, and 52. By comparing information extracted from Figure 8, the designer can find correlated relationships between adjectives and functional key phrases. In this case, the strongest score between the *comfortable* and *easy* adjectives can be linked to the functional parameter *easy handling data*.



Figure 9. Clusters based on adjectives and functional key phrases (please refer to http://amp.pharm.mssm.edu/clustergrammer/viz_sim_mats/59ce67dbc1595237b1e4fc11/Copy%2520of%2520ease_of_use_pos_adj_keyphrase_score_matrix%2520%252800000003%2529_comfortable.txt for *comfortable* adjective/function heatmap).

- *Affective/functional and patent clusters.* The trapezoidal area at the vertical ends in Figure 9 demonstrate emergence of two pair groups by functionality related to pages and data. Whereas, all the patents are grouped together in this chosen cluster subset.
- *Affective/functional patent relationships.* In this cropped sample of clusters, the patents 1, 24, 29, and 52 have many common relationships with adjective#functional key phrase pairs. However, the strength of these relationships vary between them. Comparing this particular cluster with generated function list (Appendix 2) and IPC codes (Appendix 3) yields no common entity between all of them. This comparison demonstrates the advantage of using crowd responses to generate abstracted functional clusters with reference to adjectives. In this case, the abstracted common functional key phrases are related to paper book similarity, inserting data and decisions. Patent 4 is closest to patent 50 and patent 60 in Figure 8, but they are not the closest patents in Figure 9 for the same *comfortable* adjective. This variation demonstrates that although there are many common adjectives found in crowd responses between patents 4, 50 and 60, but they are relatively far in terms of functional entities.

Discussion

The heatmaps presented in the Analysis section above represent a new strategy for interrogating patents in relation to a particular affective parameter – *ease of use*. A similar approach

of reviewing affective, functional, and affective/functional patent clustering would be undertaken for the other (visual attractiveness, semantic) parameters. Through this initial analysis, however, we have established that by using the crowd to generate descriptions, affective relationships between patents do emerge that are not addressed by the normal IPC classifications. This provides opportunities for designers to focus on key affective terms they would like to embody in their design solutions and hone in on particular patents to support their concept generation and design embodiment work. In terms of functional relationships between patents, it was found that asking the crowd to create broader technical descriptions of patent functionality again revealed relationships that were not obvious through IPC classification or through a manual review of the set. This has advantages in finding more informal or less obvious technical links that can provide outlier, analogous or distant domain technical inspiration during concept generation. It is particularly difficult to arrive at distant but relevant patent documents through traditional search and landscaping approaches. And in generating affective/functional clusters, we established a way to visualise how affective and technical characteristics are linked. This affords the designer the opportunity to explore and understand how previous solutions have combined these characteristics: to ascertain whether this is due to the norms of the product sector, the use context, technological limitations or some other factor. Through exploration such as this, prospects for new combinations, whether driven by affective or functional requirements, can be identified.

Emerging patterns across affective parameters

Table 4 details the similarities and differences across the three affective parameters (i.e. *ease of use*, *visual attractiveness* and *semantics*) by studying the generated clusters of adjective pairs and patents in relation to the comfortable adjective. For the 5 characteristics examined, the similarities across the parameters are highlighted in bold. In reviewing patents with the most and the fewest links to *comfortable* and adjective pairs (Rows 1 and 2), it was found there was no similarity across the parameters. Indeed, patent 19 (Method and electronic device for haptic/tactile feedback) has most links to the *ease of use* parameter and fewest for the *semantics* parameter. This significant variation illustrates that the crowd responses do differentiate between affective characteristics and the resulting clusters are distinct. The common patents appearing in the largest clusters (Row 3) are patent 15 (Electronic device for displaying multiple pages by sensing e-book rotation) and patent 34 (Information Processing Apparatus, Information Processing Method, and Programme). This suggests that these patents have broad application across different modes of user interaction, and are worthy of detailed investigation on this basis. Row 4 lists closest adjectives associated with highest LESK score adjective pair with *comfortable*. While there is some commonality in terminology – *easy* is a word that is consistently identified with *comfortable* – the difference in terms reflects the nature of the parameters. For visual attractiveness, *cosy* is a word that has been used to suggest a product form or interface that is not intimidating. And the term *enough* in relation to semantics alludes to simplicity or purpose in how the product purports to function. The emerging clusters in which these adjective pairs reside (Row 5) allow the designer to explore such themes further by browsing and interrogating related terms and the associated patents.

Table 4. Similarities and differences across affective parameters for the *comfortable* adjective.

Characteristics	Ease of use	Visual attractiveness	Semantics
1. Patent(s) with most links to <i>comfortable</i> and adjective pairs	19 and 24	17	55
2. Patent(s) with fewest links to <i>comfortable</i> and adjective pairs	43 and 55	9, 12 and 56	19 and 36
3. Emergence of largest patent cluster in relation to patent(s) identified in Row 1	3, 4, 6, 7, 8, 9, 10, 12, 13, 14, 15 , 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 29, 30, 31, 34 , 36, 37, 38, 39, 40, 41, 42, 45, 46, 47, 48, 49, 50, 53, 54, 56, 60	2, 6, 15 , 17, 21, 25, 34 , 43, 55	9, 15 , 16, 24, 32, 34 , 35, 37, 46, 50, 55
4. Highest LESK score adjective pair with <i>comfortable</i>	easy	easy, cosy	easy, enough
5. Emergence of a largest adjective pair cluster with <i>comfortable</i> in relation to highest LESK score variable identified in Row 4	<i>comfortable-easy</i> pair is linked with: <i>important, excellent, different, innovative, intuitive, attractive, interesting</i>	<i>comfortable-easy</i> pair has not clustered with any other adjective pair. <i>comfortable -cosy</i> pair is linked nearest with <i>common, compatible, confused, correct, detailed, differentiated, diverse, elaborate</i>	<i>comfortable-easy</i> pair has not clustered with any other adjective pair. <i>comfortable -enough</i> pair is linked with <i>expensive</i> and <i>responsive</i>

Please refer to the following links for full heatmaps:

http://amp.pharm.mssm.edu/clustergrammer/viz_sim_mats/59ce532ec1595237b1e4fb7c/Copy%20of%20ease_of_use_pos_adj_score_matrix_comfortable.txt

http://amp.pharm.mssm.edu/clustergrammer/viz_sim_mats/59ce7f90c1595237b1e4fc98/visual_adj_score_matrix_comfortable.txt

http://amp.pharm.mssm.edu/clustergrammer/viz_sim_mats/59ce8826c1595237b1e4fcea/Semantics_easy_of_of_use_Comfortable.txt

Scenario of implementation

To illustrate how this work could be implemented in product development workflows, we have set out a scenario, the main phases of which are shown in Figure 10. The mechanics of each phase are described using the ebook reader and patent set from our analysis above.

Patent set preparation

By way of preparation, a relevant patent set is secured through preliminary research. The set of 60 used in our evaluations provides a manageable number to navigate and explore in depth. With larger patent sets this becomes increasingly time consuming and therefore consideration should be given to the breadth and volume sourced for a given problem. Patents are widely available through a number of online databases (e.g. <https://worldwide.espacenet.com/>). At this point, the designer chooses interesting and relevant affective parameters (e.g. *appearance, ease of use, or semantics*) to be incorporated in the product under development. Based on the chosen patent set and affective parameters, the proposed landscaping technique will generate all the required explorative and clustering visualisations necessary for the subsequent phases through a combination of crowdsourcing and data processing.

Cluster generation

In this instance, we consider the *ease of use* parameter. When the data processing is complete, the designer can engage in the exploration of frequent, common and unique

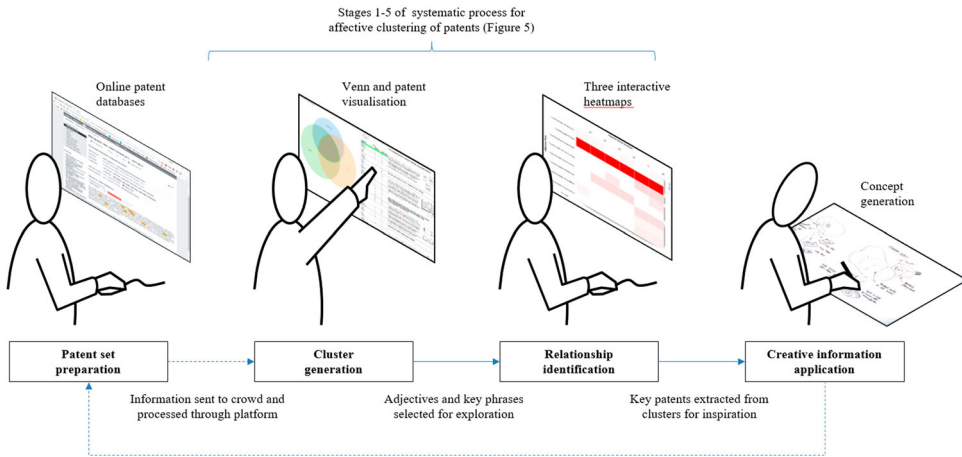


Figure 10. Demonstrating use of the affective landscaping of patents to support technological idea generation.

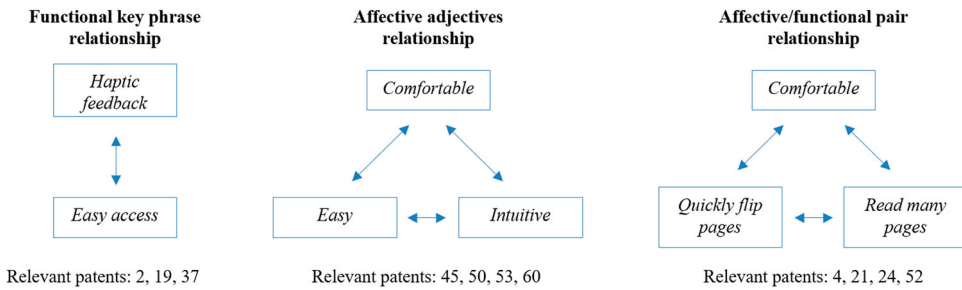


Figure 11. Illustrative cluster examples across functional key phrase, affective adjective, or affective/functional pairs for ease of use parameter.

adjectives as well as the functional descriptions generated in the crowd’s responses to this parameter through interactive web-based Venn diagrams (see Figure 5 above). Using the side-by-side patent set and adjective list visualisation of the interface, adjectives and key functional phrases can be identified. For example, for the ebook reader with respect to *ease of use*, the adjective *comfortable* and the functional term *haptic feedback* were prominent.

Relationship identification

To explore how the identified characteristics can be embodied in the ebook reader, the designer can examine the relevant patents and their groupings. This is accomplished through the heatmaps described above (Figures 7–9), with Figure 11 summarising some of the relationships identified from these figures and the relevant patents for each.

Creative information application

Focussing on the functional key phrase grouping, the common functional characteristics and affective adjectives associated with *comfortable* can be examined in more detail (Figure 12). In interrogating these, we find that patent 19 has a much larger list of affective terms that are not used in the other two patents. This is cause to explore the characteristics

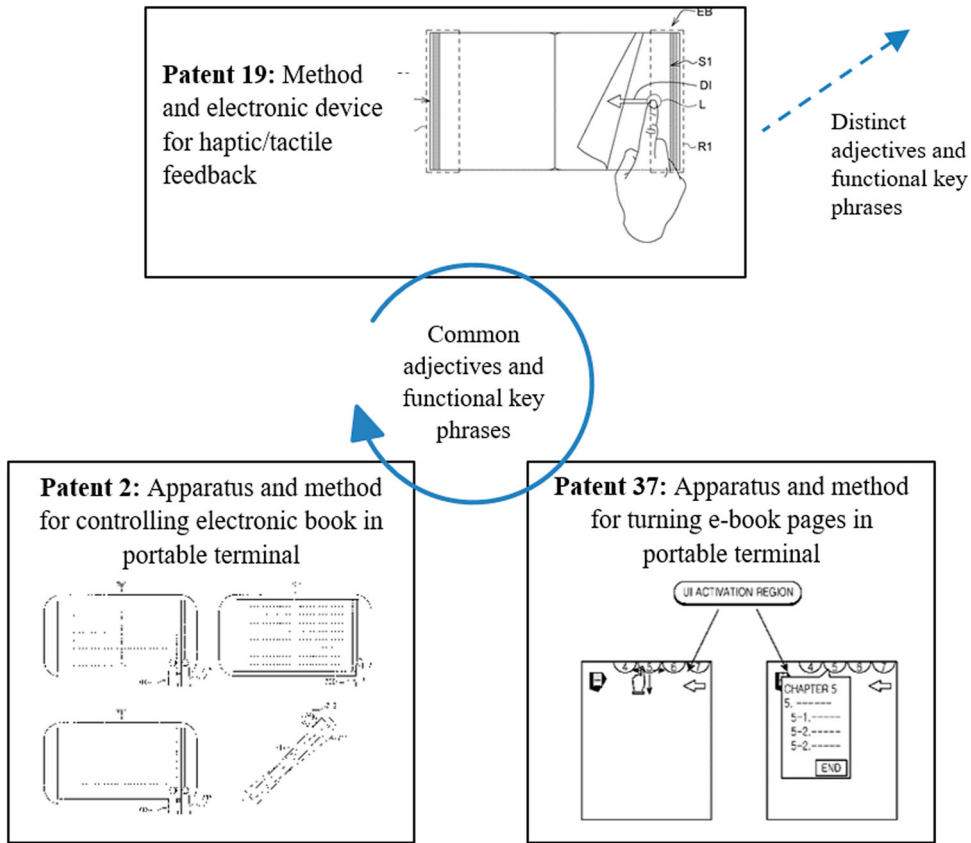


Figure 12. Commonality between three patents with comfortable as a focus element.

of this patent in more detail: it is a page turner with particular interactive characteristics. So while the other two patents deliver page turning by more mechanical or procedural means to achieve navigation, the human-centric embodiment of this solution means it is a useful reference point if we are considering how to incorporate *ease-of-use*, *comfort* and *haptics* in to a design. A similar process can be followed using adjectives or the affective/functional groupings. And there is scope for articulating this approach with structured creative techniques such as SCAMPER (Eberle 1972) to prompt the assimilation of particular characteristics from the emerging list of terms.

Future development

The ability to interrogate the database through affective parameters gives designers the ability to ask new questions that would not normally be equated by this particular form of big data: What indicators can be monitored to best understand user response during product use? Do user requirements change through the ageing process with respect to motivation, learning and dexterity? How can tasks and activities be designed and sequenced to form compelling narratives of use? How can factors such as culture, personality, experience be considered in interface design? And can the tensions between tailored

individual requirements and product universality be resolved in unifying design principles? In performing this analysis, we have established the possibility of connecting patents with a range of user experiences, including physical operation, visual interrogation, and context of use. We anticipate that in answering the above questions, these connections can help reveal tangible and inspirational insights for concept generation. In addition, they provide a potential means to access technical information to support developmental and embodiment work that, while detailed, is oriented and presented with user-related issues in mind. However, the next step is to take the visualisations we have produced and to undertake testing in a range of use case scenarios. By taking a number of different concept design problems that are framed by one or more user-centred issue, appropriate visualisations can be produced for interrogation during the concept generation and embodiment processes. Our intention would be to monitor and report on their subsequent effect on design output, as well as qualitative feedback from designers on their usability. Additionally, our current model dictates that the crowd creates bespoke affective adjectives for each patent set in relation to a particular design problem. Reusing the adjectives created in prior exercises by linking design problems affords the possibility of building and developing a more expansive affective database that can be readily applied based on the design context.

Limitations

There are limitations in the existing analysis that should also be considered. Firstly, the patent set utilised in analysis will impact on the emerging clusters. We have focussed on traditional ('utility') patents that deal with functional design, and encompass a wide range of functionality. While we did consider utilising the patent database of 'registered designs' that deals primarily with shape and appearance, these do not contain any design detail. So although they may provide a more obvious link to affective parameters, they would be limited in supporting innovative engineering design. In future work we would consider utilising the registered designs to explore the differences in terms of clustering and whether any useful technical insights could be gained through crowd responses and interpretation of the information that is available. Through the crowd there is also potential to set tasks that will link aesthetic design protections with corresponding utility patents and therefore offer further means of accessing the databases. Furthermore, we have focussed on patents used in a particular consumer product setting, and have not addressed highly specialist or technical patents. In doing so, there may need to be a further filtering process to ensure the quality of responses was adequate. It would therefore be desirable to run multiple tests on different types of patent set. And finally the patent set size is a factor in the effective harvesting of responses. We have produced a semi-automated system that utilises existing crowdsourcing platforms, a web interface and Excel spreadsheets. This we believe to be scalable to a certain degree, and there are enough workers in the global pool interested and available to accommodate much larger patent sets. In terms of the current configuration, however, working with databases beyond a few hundred patents would require greater automation of the system. The system architecture is something we will continue to develop and refine in future iterations. The nature of the crowd itself has a significant impact on the effectiveness of this approach. We have used test questions to establish a level of competence but there were no demographic or academic barriers to

crowd participation: they were not designers. In a sense, this was desirable as we were asking them to put themselves in the position of users or consumers of the patents – while also having the facility to understand their technical content. Relying on test questions and quality control was our approach to gathering sufficient responses, but in longer-term work on a bespoke platform crowd curation and development of a key core of workers would be advantageous. Other factors that could affect cluster formation and should be considered in future work include the possibility of an increasing disparity of subjective judgements as the crowd size increases, and the effect of different algorithms in measuring semantic relatedness.

Conclusions

This work has set out a new means for interpreting big data in the form of the patent database to provide insights into the affective qualities of patents and the relationships that emerge through consideration of their affective parameters. It has resulted in a defined workflow for gathering crowd responses in relation to a particular patent dataset. An interface that allows the interrogation of the resulting adjectives in relation to the patent set has been constructed. And a series of heatmaps have been produced using a combination of matrices and open-access software.

There are obviously many ways in which a patent can be implemented, and the specific product context in which it is applied has a determining effect on any emotional impact on the user. Ultimately, what the presented approach provides is an aggregated interpretation of how functional inventions might ultimately lead to affective design characteristics. The links made by crowd workers may be somewhat arbitrary when considered individually, but when aggregated we can have some confidence that there is a sound rationale for linking the technical parameters to the emotional reactions. It is our hope that the maps/visualisations produced can be used in comparison with technical maps, overlays that show a different set of priorities. Starting with the emotional implications and moving to technical possibilities may seem to be opposite from the ‘form follows function’ mantra, but this is only relevant when you don’t consider affective aspects as functions, which of course they are. If a product is more pleasurable to use, it works better. These reprioritised maps are a different perspective on what has until now been considered a purely functional resource, and point to a more holistic approach to technical information gathering for the critical and formative phase of conceptual engineering design.

Acknowledgements

This work was supported by the Engineering and Physical Sciences Research Council (EPSRC) grant reference EP/N005880/1. All data supporting this research are openly available from <http://dx.doi.org/10.15129/ec712eef-248b-49b9-b4a9-92bd4b07e760>. We are grateful to Dr Olga Kokshagina and Professor Pascal Le Masson for providing us with the e-book reader patent set.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by Engineering and Physical Sciences Research Council [grant number EP/N005880/1].

References

- Altshuller, G., H. Altov, and Lev Shulyak. 1994. *TRIZ, the Theory of Inventive Problem Solving*. Worcester, MA: Technical Innovation Center.
- Banerjee, Satanjeev, and Ted Pedersen. 2002. "An Adapted Lesk Algorithm for Word Sense Disambiguation Using WordNet." In *Computational Linguistics and Intelligent Text Processing: Third International Conference, CICLing 2002 Mexico City, Mexico, February 17–23, 2002 Proceedings*, edited by Alexander Gelbukh, 136–145. Berlin: Springer Berlin Heidelberg.
- Barnes, Cathy, and Stephen Paul Lillford. 2009. "Decision Support for the Design of Affective Products." *Journal of Engineering Design* 20 (5): 477–492. doi:10.1080/09544820902875041.
- Boyd, Danah, and Kate Crawford. 2012. "Critical Questions for Big Data." *Information, Communication & Society* 15 (5): 662–679. doi:10.1080/1369118X.2012.678878.
- Brown, Tim. 2009. *Change by Design*. New York, NY: HarperCollins.
- Bubela, Tania, E. Richard Gold, Gregory D. Graff, Daniel R. Cahoy, Dianne Nicol, and David Castle. 2013. "Patent Landscaping for Life Sciences Innovation: Toward Consistent and Transparent Practices." *Nature Biotechnology* 31: 202. doi:10.1038/nbt.2521.
- Camargo, Fabio R., and Brian Henson. 2015. "Beyond Usability: Designing for Consumers' Product Experience Using the Rasch Model." *Journal of Engineering Design* 26 (4–6): 121–139. doi:10.1080/09544828.2015.1034254.
- Chapman, Jonathan. 2005. *Emotionally Durable Design: Objects, Experiences and Empathy*. London: Earthscan.
- Clarkson, J., R. Coleman, S. Keates, and C. Lebbon. 2003. *Inclusive Design: Design for the Whole Population*. London: Springer-Verlag.
- Eberle, Robert F. 1972. "Developing Imagination Through Scamper*." *The Journal of Creative Behavior* 6 (3): 199–203. doi:10.1002/j.2162-6057.1972.tb00929.x.
- Hara, K. 2007. *Designing Design*. Zurich: Lars Muller.
- Hitchcock, D. 2005. *Patent Searching Made Easy*. 3rd ed. Raleigh, NC: Lulu Press.
- Howe, Jeff. 2006. "The Rise of Crowdsourcing." *Wired Magazine* 14 (6): 1–4.
- Hoyer, W. D., and D. J. MacInnis. 2007. *Consumer Behavior*. New York, NY: Houghton Mifflin.
- Intellectual Property Office. 2015. "The Patent Guide: A Handbook for Analysing and Interpreting Patent Data." https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/463319/The_Patents_Guide_2nd_edition.pdf.
- Ipeirotis, Panagiotis. 2010. "Demographics of Mechanical Turk." NYU Center for Digital Economy Research Working Paper CeDER-10-01. New York University.
- Jiao, Jianxin, Yiyang Zhang, and Martin Helander. 2006. "A Kansei Mining System for Affective Design." *Expert Systems with Applications* 30 (4): 658–673. doi:10.1016/j.eswa.2005.07.020.
- Kokshagina, Olga, Pascal Le Masson, and Benoit Weil. 2016. "Should We Manage the Process of Inventing? Designing for Patentability." *Research in Engineering Design*. doi:10.1007/s00163-016-0245-0.
- Krathwohl, D. R., B. S. Bloom, and B. B. Masia. 1973. *Taxonomy of Educational Objectives: The Classification of Educational Goals (Handbook II: Affective Domain)*. New York, NY: David McKay.
- Kuniavsky, Mike. 2003. *Observing the User Experience: A Practitioner's Guide to User Research*. San Francisco, CA: Morgan Kaufmann.
- Lee, S., A. Harada, and P. J. Stappers. 2002. "Pleasure with Products: Design Based Kansei." In *Pleasure with Products: Beyond Usability*, edited by W. Green, and P. Jordan, 219–229. London: Taylor & Francis.
- Le Masson, Pascal, Armand Hatchuel, Olga Kokshagina, and Benoit Weil. 2017. "Designing Techniques for Systemic Impact: Lessons From C-K Theory and Matroid Structures." *Research in Engineering Design* 28 (3): 275–298. doi:10.1007/s00163-016-0241-4.
- Lesk, Michael. 1986. "Automatic Sense Disambiguation Using Machine Readable Dictionaries: How to Tell a Pine Cone From an Ice Cream Cone." In *Proceedings of the 5th Annual International Conference on Systems Documentation*, 24–26. Toronto, ON: ACM.
- Lewis, James R. 2014. "Usability: Lessons Learned . . . and Yet to Be Learned." *International Journal of Human-Computer Interaction* 30 (9): 663–684.

- Lokman, A. M., and M. Nagamachi. 2009. "Validation of Kansei Engineering Adoption in E-Commerce Web Design." *Kansei Engineering International* 9 (1): 2–7.
- Loper, Edward, and Steven Bird. 2002. "NLTK: the Natural Language Toolkit." In *Proceedings of the ACL-02 Workshop on Effective Tools and Methodologies for Teaching Natural Language Processing and Computational Linguistics - Volume 1*, 63–70. Philadelphia: Association for Computational Linguistics.
- Maguire, Martin. 2001. "Methods to Support Human-Centred Design." *International Journal of Human-Computer Studies* 55 (4): 587–634.
- McAfee, Andrew, and Erik Brynjolfsson. 2012. "Big Data: The Management Revolution." *Harvard Business Review* 80 (10): 60–68.
- Moggridge, Bill. 2007. *Designing Interactions*. Cambridge, MA: The MIT Press.
- Montecchi, Tiziano, Davide Russo, and Ying Liu. 2013. "Searching in Cooperative Patent Classification: Comparison Between Keyword and Concept-Based Search." *Advanced Engineering Informatics* 27 (3): 335–345. doi:10.1016/j.aei.2013.02.002.
- Moser, Petra. 2013. "Patents and Innovation: Evidence From Economic History." *The Journal of Economic Perspectives* 27 (1): 23–44. doi:10.2307/41825460.
- Nagamachi, Mitsuo. 1995. "Kansei Engineering: A New Ergonomic Consumer-Oriented Technology for Product Development." *International Journal of Industrial Ergonomics* 15: 3–11.
- Nagasawa, S. 2004. "Present State of Kansei Engineering in Japan." Paper presented at the IEEE International Conference on Systems, Man and Cybernetics, The Hague, October 10–13.
- Norman, D. 2004. *Emotional Design: Why We Love (or Hate) Everyday Things*. New York: Basic Books.
- Nurkka, Piia, Sari Kujala, and Kirsi Kempainen. 2009. "Capturing Users' Perceptions of Valuable Experience and Meaning." *Journal of Engineering Design* 20 (5): 449–465. doi:10.1080/09544820903158835.
- Özcan, Elif, Gerald C. Cupchik, and Hendrik N. J. Schifferstein. 2017. "Auditory and Visual Contributions to Affective Product Quality." *International Journal of Design* 11 (1): 35–50.
- Pedersen, Ted, Siddharth Patwardhan, and Jason Michelizzi. 2004. "WordNet: Similarity: Measuring the Relatedness of Concepts." In *Demonstration Papers at HLT-NAACL 2004*, 38–41, Boston, Massachusetts: Association for Computational Linguistics, May 02–07, 2004.
- Rose, Stuart., Dave Engel, Nick Cramer, and Wendy Cowley. 2010. "Automatic Keyword Extraction From Individual Documents." In *Text Mining: Applications and Theory*, edited by M. W. Berry and J. Kogan, 1–20. Chichester, UK: John Wiley & Sons, Ltd. doi:10.1002/9780470689646.ch1.
- Ross, Joel, Lilly Irani, M. Six Silberman, Andrew Zaldivar, and Bill Tomlinson. 2010. "Who are the Crowdworkers?: Shifting Demographics in Mechanical Turk." In *CHI '10 Extended Abstracts on Human Factors in Computing Systems*, 2863–2872. Atlanta: ACM.
- Ryley, James F., Jeff Saffer, and Andy Gibbs. 2008. "Advanced Document Retrieval Techniques for Patent Research." *World Patent Information* 30 (3): 238–243. doi:10.1016/j.wpi.2008.01.004.
- Seels, Barbara, and Zita Glasgow. 1990. *Exercises in Instructional Design*. Columbus, OH: Merrill.
- Vasantha, Gokula., Corney Jonathan, Maclachlan Ross, and Wodehouse Andrew. 2016. "The Analysis and Presentation of Patents to Support Engineering Design." In 7th International Conference on Design Computing and Cognition (DCC16), Chicago, USA.
- Wodehouse, Andrew., Vasantha Gokula, Corney Jonathan, Maclachlan Ross, and Jagadeesan Ananda. 2017. "The Generation of Problem-Focussed Patentclusters: A Comparative Analysis of Crowd Intelligence with Algorithmic and Expert Approaches." *Design Science* 3. doi:10.1017/dsj.2017.19.
- World Intellectual Property Organization. 2016. "WIPO IP Facts and Figures 2016." Geneva. http://www.wipo.int/edocs/pubdocs/en/wipo_pub_943_2016.pdf.
- Yanagisawa, Hideyoshi. 2011. "Kansei Quality in Product Design." In *Emotional Engineering: Service Development*, edited by Shuichi Fukuda, 289–310. London: Springer London.
- Yoon, Janghyeok, Hyunseok Park, and Kwangsoo Kim. 2013. "Identifying Technological Competition Trends for R&D Planning Using Dynamic Patent Maps: SAO-Based Content Analysis." *Scientometrics* 94 (1): 313–331. doi:10.1007/s11192-012-0830-6.

Appendix 1

60 patent dataset.

	Patent number	Patent title
1	WO201439286	Synchronizing multiple reading positions in electronic books
2	EP2701049	Apparatus and method for controlling electronic book in portable terminal
3	US20130319209	Distribution of Audio Sheet Music As An Electronic Book
4	US20130298067	Thumbmarking in an E-Book Reader with Multitouch
5	EP2650770	Bookmark setting method of e-book, and apparatus thereof
6	US20130268847	System and method for displaying pages of e-book
7	WO2013154318	Deformable display device and method for controlling thereof
8	KR20130088695	Page display method and apparatus
9	WO2013129858	Method for displaying pages of e-book and mobile device adaptedthereto
10	WO2013129857	Method and apparatus for turning pages in terminal
11	WO2013115499	Method and apparatus for displaying page in terminal
12	US20130159914	Method for displaying page shape and display apparatus thereof
13	EP2608007	Method and apparatus for providing a multi-touch interaction in a portable terminal
14	WO201382135	Incremental page transitions on electronic paper displays
15	US20130127912	Electronic device
16	EP2592541	System and method for executing an e-book reading application in an electronic device
17	EP2587361	Method and apparatus for displaying e-book in terminal having function of e-book reader
18	WO201358545	Electronic book apparatus and user interface providing methodof the same
19	US20130088438	Method and electronic device for haptic/tactile feedback
20	WO201335724	Electronic book display device that performs page turning in response to user operation pressing screen, page turning method, and programme
21	US20130024767	E-book terminal and method for switching a screen
22	JP2012221308	Display device, processor, display method and display programme
23	WO2012131464	Method for three-dimensional viewing
24	US20120240036	E-book reading location indicator
25	WO2012122386	A system and method for displaying content
26	WO2012121665	A method, system and apparatus for display and browsing of ebooks
27	US20120188154	Method and apparatus for changing a page in e-book terminal
28	US20120159373	System for and method of generating dog ear bookmarks on a touch screen device
29	WO201257897	Animated page turning
30	WO201257705	Method for fanning pages of an electronic book on a handheld apparatus for consuming electronic books
31	EP2444887	Method and apparatus for turning pages in e-book reader
32	WO201252859	Simulating and controlling a page turn effect on an electronic device
33	US20120092243	Processing method for a device having a bi-stable display and apparatus
34	US20120089938	Information processing apparatus, information processing method, and programme
35	EP2437153	Apparatus and method for turning e-book pages in portable terminal
36	EP2437154	Apparatus and method for turning e-book pages in portable terminal
37	EP2437151	Apparatus and method for turning e-book pages in portable terminal
38	US20120084647	Information processing apparatus, information processing method, and programme
39	US20120084646	Information processing apparatus, information processing method, and programme
40	CN102375658	Interface display method and device for electronic readings
41	US20120066591	Virtual Page Turn and Page Flip via a Touch Sensitive Curved, Stepped, or Angled Surface Side Edge(s) of an Electronic Reading Device
42	US20120047470	Method and apparatus for browsing an electronic book on a touch screen display
43	KR101680349B1	Mobile terminal and control method thereof
44	EP2402870	Method for managing usage history of e-book and terminal performing the method
45	US20130007611	Electronic reader and page flipping method thereof
46	WO2011105996	Skipping through electronic content on an electronic device
47	WO201185386	Electronic text manipulation and display
48	US20110050594	Touch-screen user interface
49	EP2287710	Method and apparatus of electronic paper comprising a user interface
50	US20120102425	Electronic apparatus and page flipping method therefor
51	WO2010148084	Integrating digital book and zoom interface displays
52	WO201080258	Virtual page turn
53	US20100141605	Flexible display device and data displaying method thereof

(continued).

	Patent number	Patent title
54	US20100045616	Electronic device capable of showing page flip effect and method thereof
55	EP2104026	Reproducing method of electronic document
56	US20070048717	Electronic book reading apparatus and method
57	WO200586133	A method, system, apparatus, and computer programme product forcontrolling and browsing virtual book
58	WO200468303	A programmable virtual book system
59	WO200231698	Method and system for advertisement using internet browser with book-line interface
60	WO200131425	Electronic book display, electronic book displaying method, and computer-readable recorded medium on which electronic book displaying programme is recorded

Appendix 2

Function list generated manually from abstracts for the 60 patent dataset.

Functions	Patent Serial Number
3D-imaging	23,26,29
Bookmarking	4,5,28,48
Browsing data	26,42,57,58
Content manipulation	3,43,47,49
Deformable display	7,8,9,11,12,17,41,53
Determining page	2,21,39,50,54,56
Display multi-pages	15,18,20,29,34,40,51,52
Filters based on book size	48
Folding pages	5,6
Gesture	2,4,5,6,9,10,11,12,13,15,16,17,18,20,21,22,24,25,27,28,29,30,31,35,36,37,38,39,40,41,42,43,46,48,49,50,52,53,54,55,57,58
Haptic feedback	19
Incremental page transition	14,22,33,39,54
Location indicator	1,6,7,8,9,10,11,17,24,29,38,39,40,41,42,55,60
Motion direction	6,8,10,11,12,17,19,20,21,22,23,32,35,37,41,42,43,50,54,56
Moving/Sliding distance	17,21,32,50,54
Multi-annotations	15
Multi-touch	4,12,13,17,19,35,37,46,54,56
Multi-users	12
Music and audio playback	3
Page delete	23
Reproducing method	55
Show page thickness	60
Speed / Responsive	25,34,36,41,52,56,57
Synchronized multiple reading portions	1,3
Text to Speech	48
Texture recognition	19
Transparency/Visibility/Overlap	24,33,39,52,59
Turning page/Fanning	2,10,11,16,19,20,21,22,23,24,27,29,30,31,32,33,34,35,36,37,38,39,40,41,42,45,46,48,49,50,52,54,55,56,57,58,59
Usage history	44
Zoom/Reduce size	25,51

Appendix 3

IPC code classifications for the 60 patent dataset.

Sub-class	Description	Group	Description	Patent Serial Number
G06 COMPUTING; CALCULATING; COUNTING				
F1	Details not covered by groups	16	Constructional details or arrangements	2, 27, 35, 36, 37
F13	Interconnection of, or transfer of information or other signals between, memories, input/output devices or central processing units	0		46
F15	Digital computers in general	0		46
		2	Manually operated with input through keyboard and computation using a built-in programme	51, 60
F17	Digital computing or data processing equipment or methods, specially adapted for specific functions	0		21, 23, 24, 26, 38, 39, 45
		30	Information retrieval; Database structures therefor	44, 47, 59
F3	Input arrangements for transferring data to be processed into a form capable of being handled by the computer; Output arrangements for transferring data from processing unit to output unit	0		59
		1	Input arrangements or combined input and output arrangements for interaction between user and computer	7, 11, 39, 41
		3	Arrangements for converting the position or the displacement of a member into a coded form	7, 9, 10, 11, 18
		14	Digital output to display device	1, 7, 9, 10, 11, 18, 23, 29, 51, 52
		33	Pointing devices displaced or positioned by the user; Accessories therefor	58, 60
		41	Digitisers characterised by the transducing means	9, 10, 11, 14, 15, 19, 20, 21, 48, 49, 53, 54, 52
		48	Interaction techniques based on graphical user interfaces	1, 4, 11, 14, 20, 23, 25, 28, 31, 32, 34, 35, 36, 37, 42, 49, 50, 51, 55, 52
		147	using display panels	14
		346	with detection of the device orientation or free movement in a 3D space, e.g. 3D mice, 6-DOF [six degrees of freedom] pointers using gyroscopes, accelerometers or tilt-sensors	2
		483	interaction with page-structured environments	2, 5, 12, 13, 16, 17, 27, 30, 35, 36, 37, 46, 55

(continued).

Sub-class	Description	Group	Description	Patent Serial Number
		484	for the control of specific functions or operations, e.g. selecting or manipulating an object or an image, setting a parameter value or selecting a range	40, 48
		485	Scrolling or panning	17, 30
		487	using specific features provided by the input device, e.g. functions controlled by the rotation of a mouse with dual sensing arrangements, or of the nature of the input device, e.g. tap gestures based on pressure sensed by a digitiser	45
		488	using a touch-screen or digitiser, e.g. input of commands through traced gestures	2, 5, 6, 13, 16, 17, 30, 35, 36, 37, 46, 48
F9	Arrangements for programme control, e.g. control unit	52	Programme synchronisation; Mutual exclusion,	1
T13	Animation	80	2D animation, e.g. using sprites	17
T19	Manipulating 3D models or images for computer graphics	0		17
G09 EDUCATING; CRYPTO-GRAPHY; DISPLAY; ADVERTISING; SEALS				
		4	with sound-emitters	3,
		34	by control of light from an independent source	14, 33
		0		15, 56, 57
		393	Arrangements for updating the contents of the bit-mapped memory	57
		395	Arrangements specially adapted for transferring the contents of the bit-mapped memory to the screen	14
		399	using two or more bit-mapped memories, the operations of which are switched in time, e.g. ping-pong buffers	14
G10 MUSICAL INSTRUMENTS; ACOUSTICS				
L13	Speech analysis or synthesis; speech recognition; speech or voice processing; speech or audio coding or decoding	33	Voice editing, e.g. manipulating the voice of the synthesiser	48