Evaluation of a Visual Tool for Early Patent Infringement Detection During Design

Salvatore Sorce[1], Alessio Malizia[2,3], Vito Gentile[1], Pingfei Jiang[4], Mark Atherton[4], and David Harrison[4]

[1] Università degli Studi di Palermo, Palermo, Italy
fistname.lastname@unipa.it
[2] University of Hertfordshire, Hatfield, United Kingdom
a.malizia@herts.ac.uk
[3] Molde University College, Molde, Norway
[4] Brunel University London, United Kingdom
firstname.lastname@brunel.ac.uk

Abstract. Patent infringement detection usually implies research among documents in different forms, in both natural and unstructured language, often involving a lot of human resources and time. In order to ease this patent check process, we previously presented a visual tool to be used by designers themselves at any stage of the design process, providing them with useful and reliable information for deciding whether to steer their design away from potential patent infringements. In this work, we report on a usability study carried out on such a tool with 21 professional designers from industry in the field of mechanical engineering. The outcome of our study shows that our tool is very well accepted by designers, and felt useful and helpful even by legal experts.

Keywords: Visual interfaces · Visual programming · Block programming · End-user programming · Patent infringement detection.

1 Introduction

Product design mainly relies on the capability of inventors to produce suitable products or parts for the task they have to accomplish. Unfortunately, in the industry world functionalities and geometry are not the only drivers of the inventors' design. Indeed, there are patents to deal with, which cover products, parts, and even functionalities. Patents are often represented in the form of PDF documents, possibly scanned from their original hard copies, thus making any search difficult. Furthermore, the features covered are often described in natural, unstructured, language, with no technical details, aiming at not clearly revealing the covered design itself. Last, but not least, the patent check process occurs only at a stage of design by which it has already involved a lot of human resources and time, which is too late for re-design to be economically feasible. For this reason, legal disputes on patents are time- and money-consuming, and even if only a small percentage of disputes reach the court, they strongly affect the life of both the supposed infringers and infringed.

Based on this situation, during a project on intellectual property defence we were involved in [11], we set up a visual software tool to be used unobtrusively by designers at any stage of the design process, in order to give them useful and reliable information for deciding whether to steer their design away from potential patent infringements [17]. The visual tool is based on portable web technologies, and relies on an available semantic database for patent representation [2].

In this paper, we report on a user study we carried out with participants from industry in the field of mechanical engineering, who were neither part nor aware both of the tool and of the project before the study itself. For our study, we involved 21 professional designers, and we used well known questionnaires to assess perceived usability, usefulness and workload of the tool. The outcome of our study shows that such a tool is very well accepted by designers, and felt useful and helpful even by legal experts. In particular, for our tool we obtained good values for all the metrics we used, and also a good overall acceptance as a side-instrument to be used even since the beginning of the design process.

2 Background and Related Work

Patent infringement is the commission of a prohibited act with respect to a patented invention without permission from the patent holder. The test for infringement requires that the infringing party's product falls within one or more of the claims of the patent. The first claim defines the distinguishing technical features that set the invention apart from the prior art. When designers make judgements on intellectual property their analysis usually relies on the graphical/visual descriptions of the patented invention (e.g. images, sketches) in addition to the textual information provided with the patent. Indeed, patent analysis has been proved to be able to provide an efficient way to study and understand prior art, allowing to gather valuable information such as technological details and market opportunities [8, 14]. Research conducted by Cascini and Zini used function trees to represent components of an invention in order to measure patent similarities [7]. Other researchers investigated effective ways of visualising patent analysis [8, 12]. Li et al. worked on patent claim mapping in identifying patent claim conflicts [15]. The majority of research on patents serves professionals who work closely with patents such as patent analysts, Research and Development specialists, suggesting that research in assisting designers to understand patents and identify emerging design-prior art conflict has been overlooked to date.

In order to assess on patent infringement, experts often use text-based patent search or retrieval systems [1, 5], which typically involves a keyword search. The semantics of these keywords will affect the quality of the results obtained, and so other techniques including natural language processing (NLP), statistical inference and machine learning (e.g. IBM Watson SIIP platform [10]) are used to improve results. However, text-based techniques are problematical [4] and generic patent image retrieval approaches (e.g. [19]) do not effectively capture the important working principle of the design [15]. Patent image retrieval systems such as Patseek and PatMedia [4] search for visual similarity of images, which is not necessarily a similar working principle, whereas a common working principle between designs suggests a potential conflict with the prior art.

It is worth noting that many of the systems and tools for patent analysis mentioned above require additional knowledge for designers to deal with query languages or patterns that normally are not part of their background.

To solve these issues, and in contrast with prior work, we previously presented a visual interface for helping designers to access prior art via a semantic database without requiring any specific background on query languages [17]. The interface design allows users to exploit block-oriented programming [18], presenting a program logic based on compositions of visual blocks. In this paper we report on a usability study on such a tool.

3 The Visual Tool

The automatic patent analysis follows a well-established workflow [1], which is based on a suitable machine-readable patents representation, and on a further patent analysis system, which in turn could be full- or semi-automatic.

Our visual tool represents the front-end for a patent analysis framework that focuses on mechanical engineering and is based on a semantic database. The database includes mechanical products covered by patents, and it is composed of a patent functional representation and a domain-specific ontology [2]. The functional representation aims at expressing patents in terms of geometric features and their functional interactions. The domain-specific ontology enables knowledge sharing and conceptualisation, providing a standardised vocabulary for describing patented designs. The vocabulary, the relationships among geometric features and their functional interactions are encoded in a semantic database; this structured representation models similar working principles be-

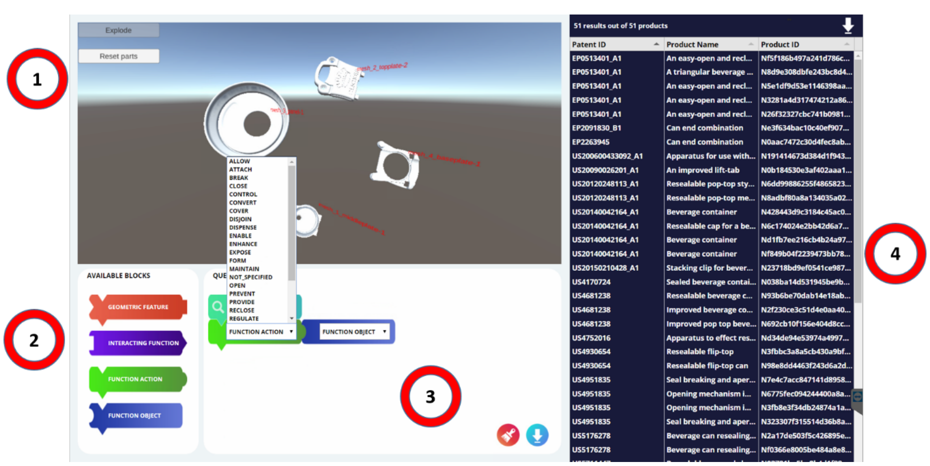

Fig. 1. The interface layout.

tween an emerging design and prior art. The whole framework allows for early identification of potential conflicts and thereby can help designers steer their emerging designs away from overlapping patents.

Figure 1 shows the interface layout, whose symbols meaning and operational principles are described in [17].

4 Study Design

After the encouraging results of a preliminary evaluation of our visual tool [17], we decided to carry out a more structured study in order to assess the perceived usability, usefulness and workload. To this end, we recruited 21 professional designers from five industries as participants (3 females, 18 males, age ranging between 20-62 y.o., $M = 35.7$, $SD = 13.0$). This allowed us to collect a suitable amount of data for a meaningful analysis. In the following, we name the industry partners with five labels: BB, SN, CT, WFO and JR.

None of the participants were colourblind, while 11 were visually impaired (wearing glasses or contact lenses). 7 participants were involved in the patent infringement detection process; in particular:

– BB users were all involved in the process, mostly for legal aspects;
– only one SN user out of two was involved, for legal aspects;
– two CN users out of five were involved, for design and legal aspects;
– none of the three WFO users were involved in the process;
– none of the seven JR users were involved in the process.

We prepared 3 scenarios with 5, 5, and 7 tasks each respectively, and all participants were asked to accomplish them. All the participant industries allowed us into their premises upon appointment, and they let their employees leave their workplaces for the time needed for the test. The apparatus consisted of a laptop PC running our web-based visual interface. The users came up one after the other, and we asked the tested user to not reveal what we asked them and what they did to upcoming ones. For each test, after a brief explanation of the context, the experimenter started asking the user to complete each of the three scenarios one after the other, with a short pause between them. For each scenario, the final goal consisted of subsequent tasks, each depending on the previous one, except the first. The experimenter asked users to accomplish the planned tasks, by reading the goals in terms of queries expressed in natural language (e.g.: "Search for products that provide opening"; "Search for products having rivets on a plate"). The users were also asked to comment aloud their actions, in order to give the experimenter the opportunity to take note of them. The goal of each task was to compose the corresponding query on the visual tool, with no hints on the tool and in particular on how to start. The whole test took 5 sessions along three days (2 sessions a.m. and p.m. in the first two days, 1 session all day long for the third day). There was no time limits for each test, and they lasted 21 minutes at least and 45 minutes at most.

At the end of each test, we submitted 5 questionnaires to each user, both structured and free-text:

- Raw NASA Task Load Index (NASA-TLX - workload assessment) [9]
- System Usability Scale (SUS - usability assessment) [6]
- Usability Metric for User Experience (UMUX-Lite - usability assessment) [13]
- Net Promoter Score (NPS - satisfaction assessment) [16]
- Demographic + personal free suggestions

We let users complete the questionnaires all alone, being available for any request of clarification if needed. We also collected the experimenter's notes taken during the tests, for an additional qualitative cognitive walkthrough.

5 Results

The **NASA-TLX** questionnaire allows to evaluate the overall perceived workload in terms of mental demand, physical demand, temporal demand, achieved performance, required effort, and frustration level. Table 1 shows the results of the NASA-TLX questionnaire. It is worth noting that we had the highest counts in the positive parts of each scale, showing a positive evaluation of the perceived workload in terms of its components. Indeed, we had the highest counts on values less or equal than 30 for mental demand, physical demand, temporal demand, effort and frustration level, and on values greater or equal than 80.

Concerning the overall perceived workload across the 21 users resulting from the values of each dimension, we had an average value of 44/100. We observed higher counts on low values of perceived workload in the age range 29-65, with 15 questionnaires resulting in values in the range 29-47, and 6 resulting in values in the range 47-65.

The **SUS** questionnaire allowed us to obtain a usability level, which is also comparable to any other outcome from SUS questionnaires. We obtained an overall average SUS score of 70.36 ($SD = 17.56$), which is considered acceptable [3].

The **UMUX-Lite** questionnaire provides a measure of perceived usefulness and usability. Figure 2 shows a two-dimensional quadrant in which values of perceived usability and usefulness are reported for each user. In this case, we had an overall positive feedback, with 5 users in the bottom-left part of the quadrant, and 16 in the top-right part. In more detail, concerning the usefulness, we had 16 users who rated our tool with a 4 or more. As far as the usability is concerned,

Table 1. Workload values count, resulting from the NASA-TLX questionnaires.

	Min	AVG	Max	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Mental Demand	15	47.14	90	0	0	1	0	3	5	1	1	0	3	0	2	0	1	0	2	1	1	0	0
Physical Demand	5	22.38	55	4	5	2	2	1	1	1	2	0	1	2	0	0	0	0	0	0	0	0	0
Temporal Demand	5	36.43	85	1	0	2	2	4	1	3	1	2	1	0	2	0	1	0	0	1	0	0	0
Performance	20	76.67	100	0	0	0	1	0	1	0	0	0	0	0	0	1	1	3	6	2	5	0	1
Effort	10	42.38	80	0	1	1	0	2	4	2	2	3	0	0	3	0	1	0	2	0	0	0	0
Frustration Level	10	40.71	90	0	2	4	0	0	3	2	2	1	1	1	1	0	0	2	0	1	1	0	0

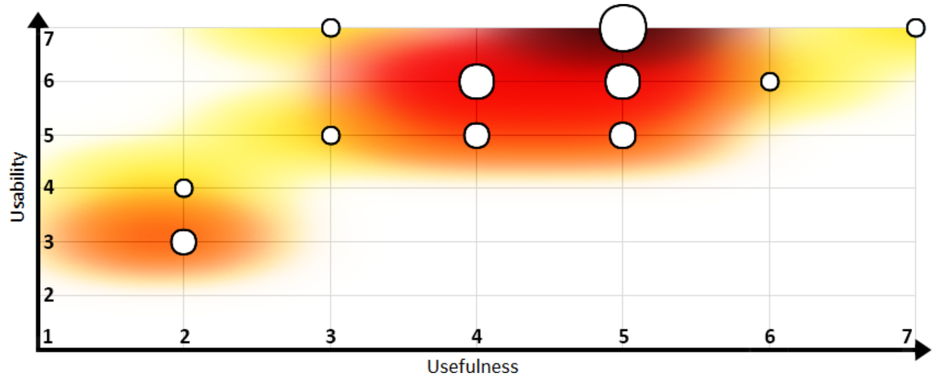

Fig. 2. UMUX-Lite results quadrant. Bigger points correspond to higher number of users who answered with that combination of usability and usefulness levels.

we had even more satisfying results, with 19 users who rated our tool with a 4 or more (18 users rated the usability with 5 or more).

The **NPS** is based on a single 11-point scale, and it aims at assessing the users' satisfaction by means of how much they would likely recommend the tool to their colleagues. In this case, we had 6/21 detractors (29% - scored 0-6), 10/21 promoters (48% - scored 9-10) and 5/21 passive (24% - scored 7-8), leading to an overall positive NPS [16]. We obtained the highest average evaluation from youngest users, who were also not involved in the legal aspects of patent infringement detection. Above all, participants who found the tool very useful reported that they would check for a possible patent infringement before the legal department would take care of it. In other words, they would enjoy the possibility to have some early hint on possible patent infringement, in order to decide whether to steer their design away, or to consciously pursue the current idea.

5.1 Cognitive walkthrough

During the tests users mentioned some issues that may have had an impact in lowering the perceived usability:

1. inability to immediately understand how to interact for the very first task (mentioned by 18 users, i.e. 86%), although proceeding quickly thereafter
2. inability or difficulty in guessing the drag-and-drop feature (mentioned by 13 users, i.e. 62%), or where to drop the selected block (8 users, i.e. 38%)
3. confusion caused by the magnifying glass icon (mentioned by 14 users, i.e. 67%), usually associated with search features, while here indicating the starting point to compose a query. 14 users (67%) mentioned similar issues due to the brush-shaped button used to clear the query, which caused confusion due to the resemblance with the icon often used for the format copy-and-paste
4. all the participants found the 3D visualisation not relevant for the tasks

Some of the above may be easily solved by tweaking with icons and visual clues, or by adding simple features (e.g. ability to close the 3D view). Although we did not test how such changes would improve user experience, it is likely that they would increase the perceived usability.

5.2 Discussion

The analysis of the study results gave us some useful hint on both the current design choices and how to change them, where needed. In particular, we observed that most of the "negative" evaluations or comments were related to the very starting phase of the interaction. Once users filled the cognitive gap, they proceeded very fast, thus showing that such gap was very little and the learning path very short. This means that in a real scenario, where users would be suitably trained in using such a tool, they would only enjoy the features of the tool they appreciated. It is worth recalling that in our tests we did not give any hint on how to interact just because we wanted to have the most critical evaluation as possible.

6 Conclusion and Future Work

In this paper we reported on a study to assess the effectiveness a visual tool for early patent infringement detection, in terms of perceived workload and usability, shortly discussing the study results and extracting some general suggestion.

Based on the relevant and useful suggestions, we plan to slightly re-design the interface, by replacing the "magnifying glass" icon with a textual hint, and a shaded area as a visual hint on where to drop a block, which appears whenever a block is dragged into the "query composition" area. We plan to implement the new design and to carry out a further study on a greater number of users, aiming at obtaining some useful and significant guidelines for interface designers in the field of visual tools for professionals.

References

1. Abbas, A., Zhang, L., Khan, S.U.: A literature review on the state-of-the-art in patent analysis. World Patent Information **37**, 3 – 13 (2014). https://doi.org/10.1016/j.wpi.2013.12.006
2. Atherton, M., Jiang, P., Harrison, D., Malizia, A.: Design for invention: annotation of functional geometry interaction for representing novel working principles. Research in Engineering Design **29**(2), 245–262 (Apr 2018). https://doi.org/10.1007/s00163-017-0267-2
3. Bangor, A., Kortum, P., Miller, J.: Determining What Individual SUS Scores Mean: Adding an Adjective Rating Scale. J. Usability Studies **4**(3), 114–123 (May 2009), http://dl.acm.org/citation.cfm?id=2835587.2835589
4. Bhatti, N., Hanbury, A.: Image Search in Patents: A Review. International Journal on Document Analysis and Recognition **16**(4), 309–329 (Dec 2013). https://doi.org/10.1007/s10032-012-0197-5

5. Bonino, D., Ciaramella, A., Corno, F.: Review of the state-of-the-art in patent information and forthcoming evolutions in intelligent patent informatics. World Patent Information **32**(1), 30 – 38 (2010). https://doi.org/10.1016/j.wpi.2009.05.008
6. Brooke, J.: SUS - A quick and dirty usability scale. Usability evaluation in industry **189**(194), 4–7 (1996)
7. Cascini, G., Zini, M.: Measuring patent similarity by comparing inventions functional trees. In: Cascini, G. (ed.) Computer-Aided Innovation (CAI). pp. 31–42. Springer US, Boston, MA (2008)
8. Chen, R.: Design patent map visualization display. Expert Systems with Applications **36**(10), 12362 – 12374 (2009). https://doi.org/10.1016/j.eswa.2009.04.049
9. Hart, S.G., Staveland, L.E.: Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. In: Hancock, P.A., Meshkati, N. (eds.) Human Mental Workload, Advances in Psychology, vol. 52, pp. 139 – 183. North-Holland (1988). https://doi.org/10.1016/S0166-4115(08)62386-9
10. IBM: IBM Strategic IP Insight Platform (SIIP). https://researcher.watson.ibm.com/researcher/view_group.php?id=2134, Accessed: 2019-03-15
11. Jiang, P., Atherton, M., Sorce, S., Harrison, D., Malizia, A.: Design for invention: a framework for identifying emerging design-prior art conflict. Journal of Engineering Design **29**(10), 596–615 (2018). https://doi.org/10.1080/09544828.2018.1520204
12. Kim, Y.G., Suh, J.H., Park, S.C.: Visualization of patent analysis for emerging technology. Expert Systems with Applications **34**(3), 1804 – 1812 (2008). https://doi.org/10.1016/j.eswa.2007.01.033
13. Lewis, J.R., Utesch, B.S., Maher, D.E.: UMUX-LITE: When There's No Time for the SUS. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp. 2099–2102. CHI '13, ACM, New York, NY, USA (2013). https://doi.org/10.1145/2470654.2481287
14. Li, Z., Tate, D., Lane, C., Adams, C.: A framework for automatic triz level of invention estimation of patents using natural language processing, knowledge-transfer and patent citation metrics. Computer-Aided Design **44**(10), 987 – 1010 (2012). https://doi.org/10.1016/j.cad.2011.12.006
15. Li, Z., Atherton, M., Harrison, D.: Identifying patent conflicts: TRIZ-Led Patent Mapping. World Patent Information **39**, 11 – 23 (2014). https://doi.org/10.1016/j.wpi.2014.07.002
16. Reichheld, F.F.: The one number you need to grow. Harvard business review **81**(12), 46–54 (December 2003), http://europepmc.org/abstract/MED/14712543
17. Sorce, S., Malizia, A., Jiang, P., Atherton, M., Harrison, D.: A Novel Visual Interface to Foster Innovation in Mechanical Engineering and Protect from Patent Infringement. Journal of Physics: Conference Series **1004**, 012024 (apr 2018). https://doi.org/10.1088/1742-6596/1004/1/012024
18. Turbak, F., Bau, D., Gray, J., Kelleher, C., Sheldon, J.: Foreword. In: 2015 IEEE Blocks and Beyond Workshop (Blocks and Beyond). pp. vii–viii (Oct 2015). https://doi.org/10.1109/BLOCKS.2015.7368986
19. Vrochidis, S., Papadopoulos, S., Moumtzidou, A., Sidiropoulos, P., Pianta, E., Kompatsiaris, I.: Towards content-based patent image retrieval: A framework perspective. World Patent Information **32**(2), 94 – 106 (2010). https://doi.org/10.1016/j.wpi.2009.05.010