The *Technology Roots spectrum*: a New Visualization Tool for Identifying the Roots of a Technology

Eduardo Perez-Molina[1]

[1]*eperezmolina@icloud.com*
CTB, Universidad Politecnica de Madrid (Spain)

Introduction

The purpose of this work is to present a new tool for identifying the technological foundations, or roots, of a specific technology in the whole range of existing technologies. The idea is to go back to the date before a specific technology existed as such—its origin date—and to evaluate the influence of every existing technology in relation with it. Our tool is based on the role played by prior art patent citations as a historical footprint. The documents cited in the prior art search reports by patent examiners against patent applications in a particular —new—technology link the new emerging techniques to the conventional existing ones. The nature of this particular set of references, namely *who* produced the citations—the patent examiner in place of the author—and *why* they are cited—the evaluation of the novelty and non-obviousness—, is unique within the body of bibliographic references (Meyer, 2000), and explicitly points to temporal and conceptual proximity. These two factors seem fundamental to the study of history and technology.
The *Technology Roots spectrum* (*TR spectrum*) is a tool for visualizing the components at the origin of the specific technology under study, showing their relative weight as bars in a graph containing the whole range—the spectrum—of technologies. It uses the computer to exploit the network formed by prior-art citations in patent publications and the classification codes assigned to them. This tool can be used to study the history of technology and, as a technology indicator of technological origins, can also be used for defining technology metrics.

Data Collection Methodology

The data collection methodology is shown in Figure 1. First, we select the whole collection of patents published in a specific technology using classification codes. For example, if this technology is graphical user interfaces (GUI), we must use the IPC code G06F3/048, literally "Interaction techniques based on graphical user interfaces" (IPC codes and titles can be consulted at http://www.wipo.int/). In this way we get the specific "technology" collection. From this set we extract all the citations from its search reports building the "citations" collection. Then, we keep the patents filed before the specific technology has emerged, in this case 1975 (Reimer, 2005) and we obtain the "Roots" collection.

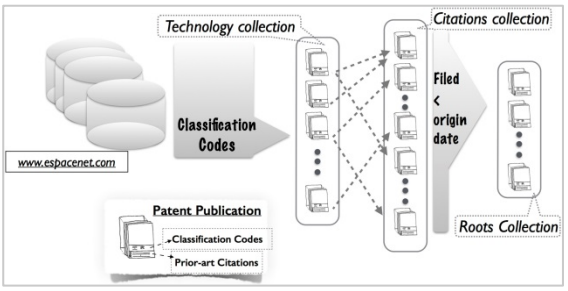

Figure 1. Data collection path

The *TR spectrum*

The set of selected patents—the "Roots" collection—is formed by patent publications disclosing technology methods, concepts, devices or systems intertwined with different aspects of the specific technology under study and filed (and therefore developed) before this technology existed —the origin's date. Analysing in turn the codes assigned to them provide us with indications of the technological foundations of the technology under study. This is why we use the expression: *Technology Roots*. Furthermore, every patent publication in the "Roots" collection is classified with a code representing a technology chosen between all possible existing technologies, this is why we use the term: *spectrum*.
The *TR spectrum* is built by aggregating the classification codes allocated to each document within the "roots" collection, and ordering this dataset in a sequence in accordance with the IPC scheme at a certain level of granularity—*section, class, sub-class, group or sub-group*—(WIPO, 2014). Changing the level of granularity we zoom out or zoom in on the techniques to have different conceptual resolutions and in consequence we can identify more technical details or we can have global views of technical fields. Figure 2 (top graph) shows the *TR spectrum* for computer graphics (CG) at the IPC *class* level. This spectrum was built using the IPC codes G06T11 (2D image generation), G06T13 (Animation), G06T15 (Image rendering), G06T17 (3D image modelling for computer graphics) and G06T19 (Manipulation of 3D models) for the "technology" collection, and the origin date was set at 1960 (Perez-Molina, 2014).
Following our methodology the "technology" collection contained 32,034 documents. Then, all

the patent publications cited in their search reports made a "citations" collection with 83,719 documents. Finally, the "roots" collection is formed by 344 patents.

A tool for studying the history of technology

The direct analysis of the main components of the spectrum provides us with an indication about the technological foundations of a specific technology. Looking, for example, at the computer graphics *TR spectrum* at IPC-*class* level (see Figure 2 top graph), it is straightforward to note that the foundations of CG are mainly in computers, electrical devices and electronics, and photography (the right-hand side of the spectrum), and to a lesser extent in medicine (left) and mechanics (left-center). The main components are G06 (computation), G01 (measuring), G09 (Education, cryptography, displays and seals), H04 (electric communications) and G03 (photography and cinematography).

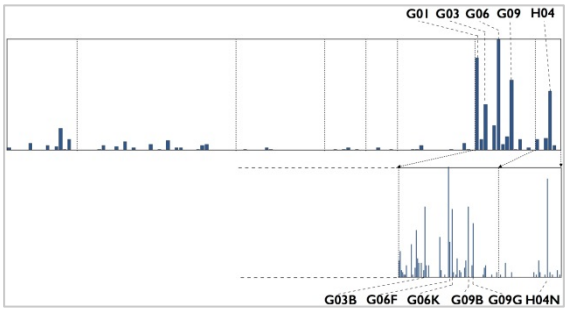

Figure 2. C.G. *TR spectrum* at IPC-*class* level (top) and partial view of the CG *TR spectrum* at IPC-*subclass* level (bottom)

At finer granularity, in other words, aggregating the dataset at the level of *sub-classes*, we have more precision in these technologies already identified. Then, it is clear from the partial view of the TR-spectrum at IPC *sub-class* level (see Figure 2 bottom graph) the importance of digital processing (G06F), television (H04N), photography (G03B), pattern recognition (G06K), educational appliances (G09B) and display control circuits (G09G). If, for instance, we are interested to know which specific technology is behind educational appliances, we zoom in on this spectral component, discovering that the most populated group is simulators (G09B9), and zooming in again we find in particular flight simulators (G09B9/08).

A tool for technology metrics

The *TR spectrum* contains information about the technological influences at the origin of a specific technology. It forms a sort of technology affiliation fingerprint of its origins, thereby it can be used as a technology identifier in technology metrics.

We have used it to get an indication of the relative distances between technologies. The different spectral bin values of the *TR spectrum* are considered as coordinates in a *technology-roots* space, thereby every particular *TR spectrum* is a point in this space. Then, applying *multi-dimensional scaling* (Wickelmaier, 2000) we have reduced the dimensionality for visualizing the relative positions of technologies. Figure 3 shows the results for four technologies—computer graphics (CG), graphical user interface (GUI), computerized tomography (CT) and Airbags—using Euclidean distance.

At present we are experimenting with other distance metrics more suitable for classification spaces.

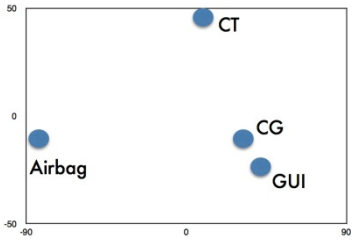

Figure 3. Relative position of CG, GUI, CT and Airbags after applying *multidimensional scaling* to its respective TR spectrums

Conclusions

We have introduced a new visualization tool—the *TR spectrum*—for identifying the technological foundations of a specific technology. We also have briefly disclosed the application of this tool for studying the history of technology and its use as a technology indicator.

References

Meyer, Martin (2000). What is special about patent citations? Differences between patent and scientific citations. *Scientometrics*, *49*(1), 93-123.

Perez-Molina, E. (2014). The Technological Roots of Computer Graphics. *IEEE Annals of the History of Computing*, *36*(3), 30-41.

Reimer, J. (2005). A History of the GUI. Retrieved, December 2014, from http://arstechnica.com/.

WIPO (2014). International Patent Classification - Guide. Retrieved, February 05, 2015, from http://www.wipo.int/export/sites/www/classifications/ipc/en/guide/guide_ipc.pdf.

Wickelmaier, F. (2003, May 4). An introduction to MDS. Retrieved, May 16, 2015, from https://homepages.uni-tuebingen.de/florian.wickelmaier/pubs/Wickelmaier2003SQRU.pdf.