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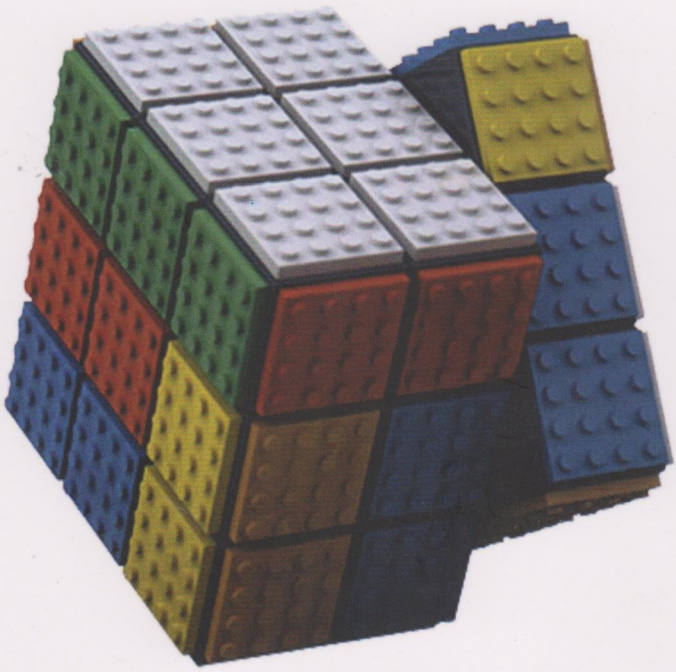
XIII. INTERNATIONAL THEORY AND HISTORY OF ARCHITECTURE CONFERENCE



CONFERENCE PROCEEDINGS

DAKAM
EASTERN MEDITERRANEAN ACADEMIC RESEARCH CENTER

ARCHITECTS AS TOOL CONSUMERS: DISCOVERING TRENDS IN SOFTWARE AND PROGRAMMING LANGUAGES FOR ARCHITECTURE WITH GOOGLE TRENDS

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Abstract

Architect professional figure and skills have undergone innumerable evolutions throughout human history, and although the architect's task is always substantially to design buildings and spaces, the use of digital tools has undoubtedly marked the greatest change in architectural design since the Renaissance, if not since the time of Vitruvius (Sacchi 2018). However, when we talk about the relationship between architecture and digital tools, we immediately think about projects of some contemporary architects and researches of some important academics come to mind. Digital tools are now everywhere within the fragmented world of architecture: from multinationals firm with offices in the major cities of the world to small provincial studios, it is difficult if not impossible to find a "non-digital" designer.

The massive diffusion of digital technology has radically changed the architectural process in the last 30 years: from concept to representation, 3D modeling through CAD software up to the production of BIM models. For each of these purposes, there are now tools, made by international software houses, or by architects through programming languages, with the aim of facilitating and speeding up their work. The knowledge of certain software has become a fundamental requirement for professional practice, so that it seems in place a further differentiation of roles

within architectural firms (Peters 2018). With this article we aim to understand trends in the dissemination of software among architects, not only inside the major Architectural firms but from the whole fragmented world of architecture, exploiting the records of Google searches, analyzed through the Google Trends platform.

1 Architects and the market of Digital Tools

Important differences mark the panorama of architectural firms: while in large offices, where the need for innovation is urgent, digital practice and its potential have been fully embraced (Ceccato, 2001), so, architects create new tools capable of increasing their understanding and capability to solve architecture complexity, elsewhere the use of digital tools has often been limited to representation or to three-dimensional modeling. In any case, architects are today dependent on digital tools as they are on software houses, specialized companies that develop and market these tools, which, over 30 years since the appearance of the first commercial CAD software (Riccobono 2014), have become complex and feature-rich products specific to our professional sector, likewise it happened in other design fields.

We must also keep in mind that even those architects who exploit the full potential of digital practice, creating ad hoc tools for their singular needs, must start inside an architectural software to work with. Software that they had chosen among those available on the market and for which they must, rightly, purchase licenses, becoming de facto "consumers". A further issue, for which this research can be a starting point, is the inter-operability between software. In fact, despite software houses promotional announcements, there is no single tool able to meet all architectural design requirements: from the analysis and concept phase to the visualization, production of BIM models and technical drawings for the actual production of architectures. Thus, within the architecture studios, it is necessary to invest time and money, to make different instruments communicate with each other.

Given these premises and due to the lack of information on what and how much the different software packages are used by architects, we have tried to shed light on this important aspect, describing diffusion of software used in Architecture. To do this we could have carried out a survey to be proposed to hundreds of studies of different scale and geographical position: we would have obtained some partial information, and we would have measured ourselves with the reticence of some studies to provide information about their internal processes. Then, to obtain a global prospect, as neutral and rigorous as possible, we have therefore decided to exploit the potential of Google trends, measuring the interest in the different software used in Architecture within the global search on the Google search engine

2 Google Trends and scientific research

Google is today one of the largest tech companies in the world, its corporate mission is "to organize the world's information and make it universally accessible and useful" (Google, 2019). The company has revolutionized the way in which we access knowledge and today provides each user with customized results based on countless variables: among these, an estimated 20 petabytes per day are the information that users provide freely, plus others that the search engine is able to

legally retrieve through the extensive network of services and products offered. So anyone using the search engine has a real Digital Twin, a profile that allows Google to provide each of the more than 2 trillions of research carried out every year (Sullivan 2016) the best possible answer to our questions. The huge amount of information of searches made through Google is a great asset for the company, which shares part of this data through Google trends, a platform available for free to anyone who wants to understand how often a keyword is searched on Google.

It is crucial to specify that Google trends data are independent of research results, and cannot be influenced by marketing activities such as SEO (search engine optimization), referring exclusively to the questions we ask Google, and not to the answers we obtain from the search engine. Since Google trends launch in 2006, many researchers have exploited its potential to successfully perform research in various fields, from epidemiology (Ginsberg et al. 2009) to economics, (Baker and Fradkin 2011), geophysics (Grigoli et al. 2017), in these and other occasions more than 2 trillions of research carried out every year on Google have proved to be an important statistical asset to understand human behaviors. Others in the past have already used the platform to discover trends in software engineering, (Rech 2007) no one researched trends in software for architecture.

It is important before going into data analysis to understand how the platform works, in fact, when questioned, it does not report the total number of searches performed with the analyzed keyword, but is based on a query share: searches carried out on a specific keyword within a geographic area in a time period is divided by the total number of searches made on Google in the same area and period. The maximum value of the query share in the given period is normalized to 100 and the additional values indicate the deviation (normalized to 1) in the analyzed time frame (Choi and Varian, 2012). It is possible to carry out searches by terms or topic. It is important to note that a search by terms also includes the keywords composed by the term we are looking for, plus other words, for example, if we analyze the word “architecture” in English, google trends will not only count for the searches of the exact word, but also for “architecture jobs”.

Search by topics, only possible when the amount of query is sufficiently large, collects terms of different languages that carry same meanings, so if we look for the topic “London” we will get the results for “capital of the UK”, etc. Google also allows to differentiate the search in 30 main categories and 250 secondary categories, according to a natural language classification engine, through a probabilistic assignment: as an example, the query “apple” is assigned partially to the categories, Computer and Electronics and Food & Drink.

3 Data & Analysis

The number of software, plug-ins and programming languages used today by architects is too broad to be enumerated, functionalities offered by each program in many cases intersect, so we have therefore decided to differentiate our research into three typologies of software, based on their main features, and two further typologies including programming languages and visual programming languages used in architecture:r.

1) General Purpose CAD Software;

2) BIM software;

3) Rendering Software;
4) Visual Programming Languages;
5) Programming languages;

For each of these, when possible, we selected the most popular products, with an amount of google research sufficient to be recognized as topics, then we analyzed a period of 10 years, from January 1, 2009, to January 1, 2019, choosing the whole world as area and "Architecture" as category.

3.1 General purpose CAD software.

For the general purpose CAD software we selected: Autodesk Autocad, Rhinoceros developed by Robert McNeel & Associates, Cinema 4D by Maxon Computer of Nemetschek Group, Autodesk 3ds Max, and Sketchup a former Google initiative now developed and distributed by Trimble Inc. From Fig. 1 we can see as the most sought on Google is Autodesk Autocad, with a peak in March 2010: since then the number of searches has slowly decreased, almost constantly, maintaining however an average value of 69 of query share. Sketchup is in second position, with an average of 16, and a trend that despite the slightest variations, remains almost constant compared to the average over the last 10 years. Third, Autodesk 3ds Max, in a slight and constant decrease from the beginning of the analyzed decade, with an average value of 5. Closing our charts: Rhinoceros and Cinema 4D, which turned out to be the least sought after on Google, both with a query share average of 1.

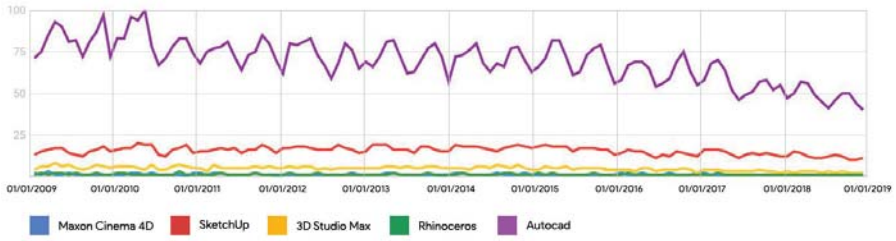

Figure 1. Query-share for general purpose CAD software within the architecture category on google trends, from 01/01/2009 to 01/01/2019.

3.2 BIM software

BIM software is, among the types analyzed, the only one created for the specific use in the AEC industry. Many governments at different levels are promoting or even forcing the realization of BIM models as a further requirement for the realization of architectures, for this reason understanding the evolution of interest in these instruments is of particular importance. Among the software and plug-ins that allow the creation of BIM models, we have selected Autodesk Revit, Bentley Microstation, VisualARQ by Asuni, then Archicad produced by Graphisoft, and Allplan, both part of the Nemetschek Group.

As shown in fig. 2, Revit is the most searched on Google, with a constantly growing trend from the beginning of the analyzed decade, a peak reached in March 2017 and an average value of 65, in second position Archicad, which in January

2009 was the most searched BIM software, saw the amount of his research drop slightly, with an average value of 28, third place Microstation, going slightly down with an average value of 8, is today closer to Allplan, in fourth place with an average value of 4, last VisualArq, which despite being recognized as an argument by Google Trends, has a query share medium value <1 compared to Revit.

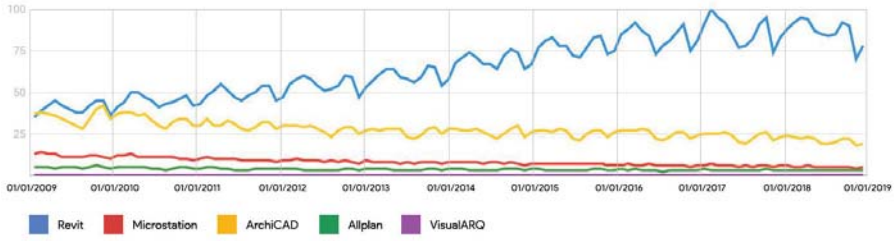

Figure 2. Query-share for BIM software within the architecture category on Google trends, from 01/01/2009 to 01/01/2019.

3.3 Rendering software

Representation has always been a fundamental element of our work as architects, yet the way in which projects are presented and communicated in recent decades has changed. In contemporary society the importance of images has become more and more accentuated, so the importance of rendering tools has increased, especially for communication purpose. Right now, numerous rendering tools available as plug-ins to be used within modeling software or as stand-alone, among these we have selected and measured (fig.3): Vray, produced and distributed Chaos Group, Crown Rendered produced by Render Legion which is also part of Chaos Group since 2017, Octane render owned by Otoy company since 2012, Maxwell Renderer, developed by Next Limit Technologies, and Renderman developed by Pixar.

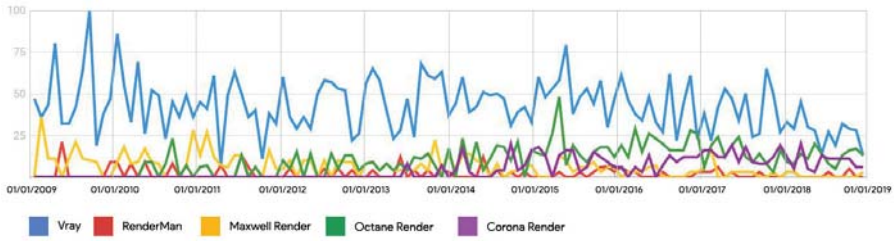

Figure 3. Query-share for rendering software within the architecture category on Google trends, from 01/01/2009 to 01/01/2019.

In this typology of software Vray is undoubtedly the most sought-after, down from the maximum of April 2009, with an average value of 43, afterwards Octane Render, which since release date has grown reaching an average of 14, followed by Maxwell Renderer and Corona renderer, the former, despite the average value of 10, has dropped significantly in the last 6 years, on the contrary Corona render denotes a positive research trend and reaches a ten-year average of 7. Last, Renderman,

which reaches an average value of 2. As evident from our graph, there is a greater discontinuity in the search trend, compared to those of the previous typologies, this is undoubtedly an indication of a lower amount of searches than the other type of software.

3.4 Visual programming languages

Visual programming languages, usable through plug-ins or as stand-alone software, were born with the intention of facilitating the use of programming languages systemic logic without the need of programming skills, thanks to a graphical interface where each command is connected to other commands and variables via lines, arrows or other representation systems. This type of languages, Grasshopper in particular, have marked the history of architectural design and research in recent years, allowing even novices in programming to create ad hoc tools for their own needs. Since not all visual programming languages are recognized as topics by Google Trends, we had to limit our analysis using search terms.

We then selected the three main VPL used in recent years in Architecture: Generative Components developed and distributed by Bentley Systems, Grasshopper, developed by David Rutten and integrated into Rhinoceros from version 6.0 and Dynamo, created by Ian Keough and available as software both as stand-alone software and within Autodesk Revit.

As can be seen from Figure 4, the VPL that has developed the most Google searches during the last decade is Dynamo, which has seen rapid growth since 2014, reaching a peak around mid-2018, with an average of 32 compared to its peak. Second, Grasshopper, which in the last 5 years has seen a slight decrease in Google searches and stands at an average value of 9 compared to the peak reached by Dynamo. Last among the three: generative components, which, despite of a number of searches comparable to those of grasshopper in the first two years of the decade analyzed, has slowly disappeared from searches on Google, reaching an average value of 1 query share.

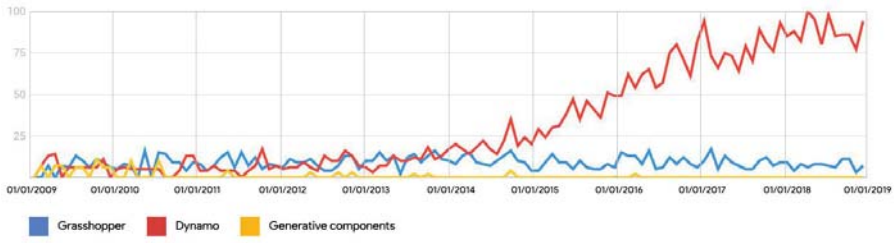

Figure 4. Query-share for visual programming languages within the architecture category on google trends, from 01/01/2009 to 01/01/2019.

3.5 Programming languages

The relationship between programming and architecture in the field of research seems to be increasingly solid (Burry, 2011), in the same way almost all the major architectural firms today have among their employees, architects capable of programming or even programmers with the task of developing customized tools and expanding commercial software. Among the programming languages

that can be integrated into CAD software we have chosen C++, the most mature and complete of the available ones, Visual Basic.net and C Sharp, both developed by Microsoft, then Ruby and Python, languages created with the declared aim of making programming easier even for non-experts. Our Chart (Fig. 5), sees C++ in first position among the most sought-after programming languages in Architecture, with a maximum reached in January 2009, with an average value of 49, followed by C Sharp, 33, next Python, growing and with an average of 18, then visual Basic. net and Ruby, both down, with an average value of 14 and 13 respectively. Even more than in figure 3, relative to rendering tools, a clear discontinuity is evident within the graphs: a clear sign that the amount of research is low and that the diffusion of programming in the Architectural field is still low. The same analysis made outside the Architecture category (Fig. 6), allows to observe how the rise of Python and the decrease of the other programming languages outside our field is more pronounced

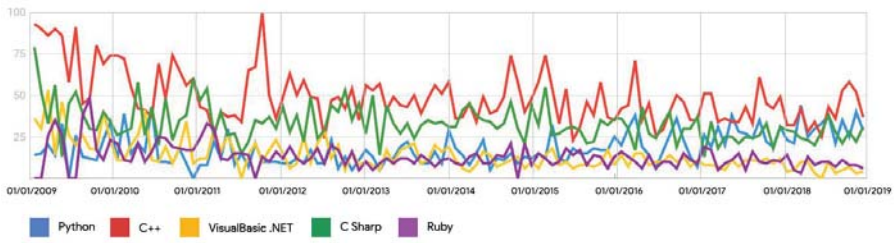

Figure 5. Query-share for programming languages within the architecture category on google trends, from 01/01/2009 to 01/01/2019.

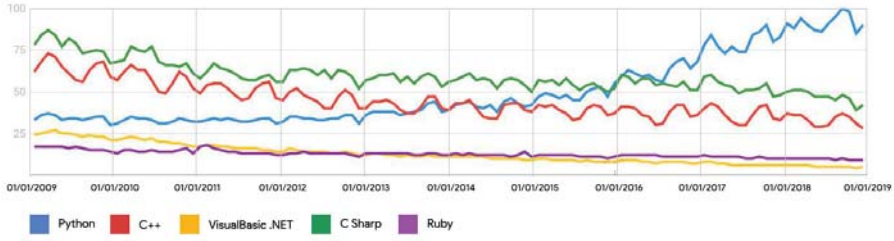

Figure 6. Query-share for programming languages within all categories on google trends, from 01/01/2009 to 01/01/2019.

3.6 General comparsion

To understand which of the five types of instruments are most sought online, we have this time chosen the maximum time range allowed by Google trends, from 2004 to 2019, we selected the highest average values queries in each typology: Autodesk Autocad for general purpose CAD Software, Autodesk Revit for BIM Software, V-Ray by Chaos Software for Rendering Software, Dynamo for Visual Programming Languages and C++ for Programming Languages.

As evident from the Chart (Figure 7), Revit and therefore BIM Software are constantly growing in interest, with a 52 average value of query share, higher than

general purpose CAD software and in particular Autocad, which is slightly going down with an average value of 19, then Vray and C++, which reach an average of 1 and Dynamo with an average value of query share <1 in architecture compared to Revit in the last 15 years.

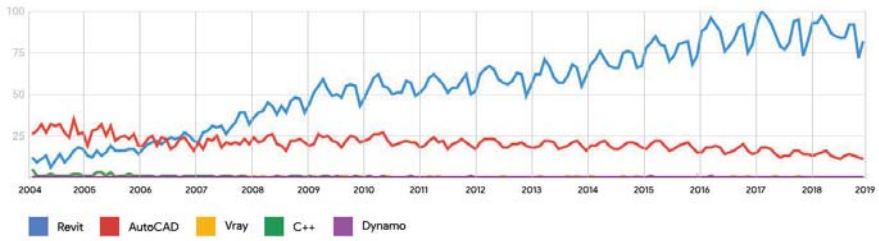

Figure 7. Query-share for the most searched tool of each typology within the architecture category on Google trends, from 01/01/2004 to 01/01/2019.

It's easy to note how until the middle of 2006 Autocad, although already in decline, had more searches than Revit. Around June the BIM Software exceeded Autocad, and never stopped growing till the end of the analyzed period.

Performing the same analysis, not just in the Architecture category, but including all Google search categories (fig.8) we see a classification reversal: with the peak reached at the beginning of 2004, C ++, determines the maximum value of the query share, its graph decreases considerably from 2004 to 2012, maintaining an average query share value of 36. In second position Autocad, with an average value of 22, slightly decreasing, with a trend which is very similar to that found in figure 7 for google searches related to architecture category, therefore Revit, which marks a slight increase and an average of 2.

Vray instead has a decreasing trend with an average of 2, and dynamo is almost invisible with a query share <1. Within the graph, we have also considered it appropriate to add Python, for a better understanding of the evolution of interests around programming languages in contemporary society.

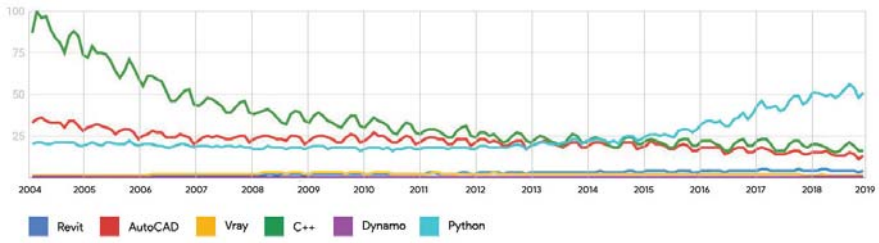

Figure 8. Query-share for the most searched tool of each typology plus Python, in all categories on Google trends, from 01/01/2004 to 01/01/2019.

4 Conclusions

Looking at Google searches in the Architecture category on the different types of software, if hypotesis that the increase in search terms is positively correlated

to the increase in competitive performance, it is clear that: Revit has become the most "interesting" software within the BIM type in the last decade, outperforming competitors and getting closer to become a standard in the fragmented world of architectural practices. By contrast, Autocad, despite the reduced capacity and expandability for the computational design, maintains a role in CAD for architecture, surpassing more powerful and versatile tools, such as Rhinoceros, which is widely used within many protagonists of contemporary architecture. That of rendering software is, despite the supremacy of Vray, the typology in which the rise of new players, particularly Corona Renderer, has been easier, even if the discontinuity of searches shows a low interest compared to other typologies of software.

The results related to visual programming languages were the most unexpected among those analyzed: if Generative Components is actually less used in recent years even in the major architectural firms, Grasshopper has become the VPL excellence among researchers and computational designers, because its greater possibilities in terms of expandability and community compared to Dynamo, which is younger and utilized within Revit, a software used at the end of the architectural workflow rather than in the concept phase. Furthermore, Dynamo was initially especially used for data export and to automate the production of technical drawings, rather than to define and optimize the Architectural shape.

The diffusion of programming in Architecture, despite the scientific research carried out within the University and some major architectural firms of the world and the enormous potential demonstrated, remains low, witnessed by the strong discontinuity in interest, and the clear difference between the search queries inside architecture category, and those in all Google categories, where Python has obtained a great interest.

The comparison between the most searched queries for each typology confirms the positive trend for BIM in Architecture, which has largely exceeded that for CAD software, still used in other sectors of design and engineering. Programming languages and rendering software, given the low amount of research compared to BIM and CAD, are less known skills. This leads us to reflect on roles differentiation within worldwide agencies, where, taking into account Google search queries, BIM competencies are increasingly requested, also because BIM is becoming a legal requirement in several countries all over the world. On the contrary, computational designers and programmers, figures currently necessary for the adoption of strategies related to artificial intelligence and the use of big data (Gallo & Pellitteri, 2018), seem to be still little diffused in everyday practice in architecture. This denotes that, despite the early diffusion of digital in Architecture (Carpo, 2016), we are still far from the spread of new methods of digital architectural design capable of marking the advent of a new architecture (Schumacher, 2011).

On the contrary, in our interpretation, the way digital tools are used marks a further differentiation among few big firms, able to invest time and resources in the adoption, development, and extension of these tools and the numerous small studies, where the adoption of digital methods meet great resistance. At the same time, the role of software houses is increasingly evident in Architecture, and it's clear how, despite the wide range of commercial and open-source digital tools, the number of companies capable of arousing interest of architects with their digital "products" is limited to a few hyper-specialized players, as already happened in

other fields of design, where the market of software is dominated by just one company.

References

Baker, S. and Fradkin, A., 2011. What drives job search? Evidence from Google search data. *Discussion Papers*, pp.10-020.

Burry, M., 2011. *Scripting cultures: Architectural design and programming*. John Wiley & Sons.

Carpo, M., 2017. *The second digital turn: design beyond intelligence*. MIT Press.

Ceccato, C. and AADipl, M.C., 2001. Integration: Master, Planner, Programmer, Builder. In *Generative Art*.

Choi, H. and Varian, H., 2012. Predicting the present with Google Trends. *Economic Record*, 88, pp.2-9.

Gallo, G. and Pellitteri, G., 2018, Luigi Moretti, from History to Parametric Architecture. In *Learning, Prototyping, and Adapting, Short Paper Proceedings of the 23rd International Conference on Computer-Aided Architectural Design Research in Asia CAADRIA*, edited by Weixin Huang, Mani Williams, Dan Luo, Yi-Sin Wu, and Yuming Ling, 209-214

Ginsberg, J., Mohebbi, M.H., Patel, R.S., Brammer, L., Smolinski, M.S. and Brilliant, L., 2009. Detecting influenza epidemics using search engine query data. *Nature*, 457(7232), p.1012.

Google. "About Google." Accessed May 17, 2019. https://about.google/intl/en-GB/.

Grigoli, F., Cesca, S., Priolo, E., Rinaldi, A.P., Clinton, J.F., Stabile, T.A., Dost, B., Fernandez, M.G., Wiemer, S. and Dahm, T., 2017. Current challenges in monitoring, discrimination, and management of induced seismicity related to underground industrial activities: A European perspective. *Reviews of Geophysics*, 55(2), pp.310-340.

Peters, B., 2018. Designing Environments and Simulating Experience: Foster+ Partners Specialist Modelling Group. *Computing the Environment: Digital Design Tools for Simulation and Visualisation of Sustainable Architecture*, pp.94-105.

Rech, J., 2007. Discovering trends in software engineering with google trend. *ACM SIGSOFT Software Engineering Notes*, 32(2), pp.1-2.

Riccobono, A., 2014. Architectural design in the Digital Era. Identifying computer influences and new expressive trends in current architecture.

Sacchi, A,. 2018. How Drawing Changes. İn *Diségno*, no. 3 (December), 131-42.

Schumacher, P., 2011. *The Autopoiesis of Architecture, Volume I: A New Framework for Architecture* (Vol. 1). John Wiley & Sons.

Sullivan, D., 2016. Google now handles at least 2 trillion searches per year. *Search Engine Land*, 24.