A data-driven approach for understanding Open Design. Mapping social interactions in collaborative processes on GitHub

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Abstract: The development and adoption of digital technologies in the past decades has modified existing working conditions and introduced new ones in many fields and disciplines. This process has also influenced the field of Design especially with the Open Design and the Maker movements. The article proposes a software library for analysing networks of social interactions over time on Git projects hosted on GitHub. Such software may be useful for understanding social interactions over time on GitHub, enabling thus an overview of participation in collaborative processes and therefore advance our understanding of how platforms connects and influence makers and designers in their collaborative work on Open Design. The article show its application to three cases of (a) discussing the nature and concepts of Open Design, (b) teaching Open Design to interaction design students, (c) the development of a platform for Maker laboratories and Open Design projects.

Keywords: Platforms, Open Design, Process, Community, Social Network Analysis

1. Introduction

The introduction of digital technologies of the past decades has enabled new forms of organization and new forms of distribution of resources or it has modified or rendered obsolete old forms. These technologies have shaped new ways of working and of participating in projects, which in turn have contributed to shaping these technologies. These phenomena haven taken place not only in software and web projects, but also in projects related to music, biotechnology, movies, science, art, design and so on (Goetz, 2003). These new conditions have often adopted practices, organizational formats and tools that revolve around the ideas of openness, collaboration, sharing of information, discussion and peer-to-peer interactions. This process has also influenced the field of Design in several ways and especially in two directions, that often overlap, where the boundaries between professional designers and amateur designers are blurry thanks to the sharing of projects and the access of digital fabrication technologies able to manufacture them locally: 1) with the Open Design movement (Abel, Evers, Klaassen, & Troxler, 2011) and 2) with the Maker movement and its Maker laboratories like

Fab Labs, Makerspaces and Hackerspaces (Anderson, 2012; Gershenfeld, 2005). On the direction of the Open Design movement (1), the Design discipline started adopting the tools and principles from Open Source and P2P software development community, opening the design processes, documentations and outcomes to digitally-enabled communities. Some authors suggests that the possibilities emerging from this intersection are broader than just the sharing and opening of design projects (Menichinelli, 2016a), along the two main directions of applying such systems in the Design practice or by facilitating, designing and enabling of such systems through the Design practice with the analysis, visualization and design of their collaborative tools, platforms, processes and organizations. Other authors tend to de-emphasize the role of technology in Open Design and adopt instead it as a broad term representing a wide range of approaches where the pre-eminence of the professional designer is not recognised in the creative process: digital technologies are important for their accelerating effect, but cases of Open Design pre-dates them (Cruickshank, 2014). One of the main topics of Open Design is therefore an increasingly complex ecosystem of tools, approaches and projects where the boundaries between professional designers and amateur designers are increasingly blurry (Atkinson, 2010; Cruickshank & Atkinson, 2014). This trend is strongly connected with the Maker movement (2), a loose global movement of individuals who focus on making physical projects but with a digital layer and digital tools, often with collaborative processes and the sharing of the digital files or documentation. Makers often meet and work in globally-networked laboratories such as Fab Labs, Makerspaces and Hackerspaces that provide access to a local and global community of like-minded actors and to several digital fabrication technologies able to manufacture easily and locally digital projects. The democratization of technology, education, content and community-building of such laboratories increases the possibilities for professional and amateur designers and at the same time it opens up new possibilities of collaboration and interaction among them and with other stakeholders. Furthermore, the Open Design and Maker movements could have an impact also in design education, especially with the emergence of the new working condition of designers-producers, as an extensive research of the Maker movement in Italy suggested (Menichinelli, Bianchini, Carosi, & Maffei, 2015).

The integration of software, data, platforms and digital fabrication technologies offer promising opportunities for actors of the Design field by enabling collaborative, open and potentially large-scale processes and systems in the design practice, research and education. Such platforms could change established practices and also offer more tools for understanding them: how could the analysis of social interactions over time on such platforms improve the understanding of design-related collaborative processes? This article aims at proposing a small contribution in this direction by providing a tool for analysing a popular platform commonly used for open source software development, GitHub[1], but also used by makers and designers. This article proposes a custom software library that reconstructs interactions among users from GitHub data (Menichinelli, 2017), and a first test of such library is done with three Open Design-related case studies. This article considers Open Design as the adoption of tools, processes and principles from Open Source software development in the Design discipline, and therefore GitHub becomes an extremely interesting case for understanding how the Open Source approach could impact the Design discipline by understanding the social interactions it enables. Moreover, GitHub is not only useful for Open Design projects, but also for discussing it, understanding it, teaching it and supporting it with custom platforms: its adoption by the Design discipline could be therefore a complex phenomenon. The

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1 https://github.com/

selection of the three cases reflects this fact. In order to shed some lights on this, the article provides an overview of:

1. the intersections of platforms, makers and designers (section 1-2);
2. existing approaches in understanding social interactions in GitHub and related tools and platforms (section 2);
3. a proposal of a software library for analysing networks of social interactions over time on GitHub (section 2);
4. its application to three cases (section 3) of
   a) discussing the nature and concepts of Open Design (section 3.2);
   b) teaching Open Design to interaction design students (section 3.3);
   c) the development of a platform for Maker laboratories and Open Design projects (section 3.4);
5. conclusions regarding the results obtained, the limits of the research and potential future directions for improving it (section 4).

2. Understanding collaborative processes on online platforms: Git and GitHub

Among the digital technologies that have had a relevant role in this process, online platforms are particularly interesting. The concept of online platform has become increasingly popular with the success of companies like Amazon, Apple, Facebook, and Google, which have based their business models less on competition and more on building ecosystems, partnerships and communities where it is easy for providers and users to participate (Simon, 2011). Online platforms are interesting for their ability to leverage the long-tail of markets and communities (Anderson, 2008), for their dimension, influence and ability of offering a place for multiple individuals or groups to get together in order to exchange goods and services (multisided platforms) (Evans & Schmalensee, 2016) or for supporting practices of collective intelligence that are environmentally aware, participatory and based on sharing and collaboration (Collective Awareness Platforms: CAPS) (Sestini, 2012). The huge dimension, impact and related ecosystems of platforms are increasingly generating attention and also criticism towards them, whatever their business model is, especially regarding their real position and influence on the social, political and economic dimensions of society. The growth of such platforms has brought side effects to society and welfare (Morozov, 2016), to politics (Epstein, 2015) and even our relationship with knowledge is affected by making us overvalue some ways of processing information over others, with novel dynamics that are not always necessarily democratic or expressions of a collective intelligence (Lynch, 2016). These critical dimensions further suggest how platforms are not necessarily always positive, stressing the importance of researching such platforms and their impact on society. The importance of platforms cannot be found only on the features and processes that they offer and their ability to scale participation up, but also on the vast amount of data they gather. This leads to the development of data-driven products and services that platforms offer, but it also enables platforms and external researchers to understand social, political and economic trends.

These platforms also extend to the design and manufacturing of physical goods thanks to the emergence of digital fabrication technologies and their democratization by commercial platforms, the Maker movement, its laboratories and platforms. Furthermore, the members of the Maker movement and especially their laboratories are already using common social media platforms like Twitter, and from their publicly available data researchers may explore the social structure and

dynamics of such movements (Menichinelli, 2016b), providing insights that could potentially lead at management and policy guidelines for improving the movement. The analysis of such platforms could then shed light on their influence on the work of makers, which are often also designers and engineers: for this reason, this article focuses on GitHub in order to make a contribution along this direction. GitHub offers free hosting for open source project development with the use of the Git[2] software for managing the history of a project developed by Linus Torvalds, the founder of the Linux project. Git was introduced for improving the development of the Linux project with an open source tool capable of managing the work of thousands of participants (Cloer, 2015). Git and GitHub have become very popular as a tool and a platform for managing software projects[3], being used not only for software projects, becoming thus a mainstream platform that also promotes an easier access to participation in open source projects (McMillan, 2013; Rogers, 2013). Understanding how developers and makers interact on projects using Git and GitHub may help understanding current and future design processes that use the same tools.

Furthermore, GitHub is an extremely popular platform with more than 49 millions projects hosted[4], and thanks to its API[5] and archived data[6] there is a strong literature about analysing and visualizing its data, from platform-scale visualizations to single-project visualizations[7]. Existing literature could be organized by approaches on analysing:
1. Git (and other version control systems) projects;
2. projects hosted on several platforms;
3. projects hosted on GitHub.

Some authors (1) have worked on analysing the structure of commits in a Git project (M. Biazzini, Monperrus, & Baudry, 2014; Marco Biazzini & Baudry, 2014); other authors have tried to analyse Git (and other version control systems) projects by developing open source softwares that create animations or static visualizations of the interactions of users through time (Caudwell, 2010; Ogawa & Ma, 2010, 2010). Some authors (2) have adopted social network analysis methods for understanding interactions on self-hosted open source platforms like Bugzilla[8] (Zanetti, Sarigol, Scholtes, Tessone, & Schweitzer, 2012) or platforms that were popular before GitHub like SourceForge (Shen & Monge, 2011) or the Apache Software Foundation[9] (Chełkowski, Gloor, & Jemielniak, 2016), or even individual projects hosted without a platform (Bird, Pattison, D'Souza, Filkov, & Devanbu, 2008). These approaches have mostly worked with social network analysis methods in order to understand latent organizations, community structure, team dynamics, participation of developers and project evolution: this has become a very popular approach that has also been investigated in its validity (Nia, Bird, Devanbu, & Filkov, 2010). Other authors have focused instead only on GitHub (3) with a similar approach (Lima, Rossi, & Musolesi, 2014; Yoshikawa, Iwata, & Sawada, 2014) and also with in-depth interviews (Dabbish, Stuart, Tsay, & Herbsleb, 2012). The social network approach has also been integrated with the geographic dimension in order to understand the global scale of collaboration on GitHub (Heller, Marschner, Rosenfeld, & Heer, 2011).

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2 https://git-scm.com/
3 An infographic of the first ten years of life of the Git project can be accessed here:
  https://www.atlassian.com/git/articles/10-years-of-git/
4 https://github.com/about
5 https://developer.github.com/v3/
6 https://www.githubarchive.org/
7 http://githubstats.com/
8 https://www.bugzilla.org/
9 http://apache.org/foundation/

Large-scale mining of GitHub data has become a popular strategy for understanding large-scale dynamics in software development, but some authors have pointed out that most projects hosted on GitHub are small, inactive or only personal, or not for software development like free storage or web hosting, or the projects are only partially hosted on GitHub (Kalliamvakou et al., 2014). These findings are similar also on related platforms like SourceForge (Rainer & Gale, 2005) or the Apache Software Foundation (Chełkowski et al., 2016).

While understanding collaboration at platform-scale might be a complex and difficult task, analysing single projects on GitHub could be an important strategy for understanding interactions among users over time. Within this direction, this article proposes a custom developed software library that analyses the interactions among users in a Git project hosted on the GitHub platform. The library is written in the Python programming language, and the interactions are mapped into networks with the use of the NetworkX library (Hagberg, Schult, & Swart, 2008). The choice of Python is based on the rich ecosystem of libraries, frameworks, documentation and users for data analysis, visualization and platform development it provides, combined with its high popularity, making it thus possible not only to analyse interactions on platform, but also to integrate such analysis in existing or new platforms with the same programming language. The library itself (Menichinelli, 2017) is open source, developed on GitHub, and it could be extended in the future to analyse other version control systems (Subversion[10], Mercurial[11]), coding development platform (BitBucket[12]) or social media platform (Twitter, YouTube, Facebook). In this way, it will be possible to understand the interactions in a project on the different online platforms it adopts for development, discussion, promotion, commercialization and so on. The library aims at providing only the reconstruction of the networks of interactions on Git (local) and GitHub (online) projects and the output and saving of such network with common data format; data analyses are left to the users which can thus adopt their favourite tools and approaches. From such interactions the library reconstructs a time-based graph for social network analysis and plotting of interactions through time: the library does not analyse individual efforts but only social interactions. The library is inspired by (but not based on) the approach taken by the TracSNAP[13] plugin for the open source self-hosted platform Trac[14] (Easterbrook, Lawson, & Strong, 2009). TracSNAP aims at understanding the networks of interactions among developers of a project managed by the Trac platform by finding them in commonality of file edits and in discussion in bug and feature tickets[15]. The library here proposed adopts two strategies for modelling interactions on Git and GitHub:

1. in Git projects, interactions are based on the editing of the same file through all the versions of a file (called *commits* in Git) ();
2. in GitHub projects, interactions are based on the Git project hosted () and on online discussions in two ways ():
   a) each user that participates in a discussion, is understood as interacting with all the previous users in the discussion;
   b) users may directly mention other users with the *@username* text like on Facebook and Twitter, and this is considered as a direct interaction.

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10   https://subversion.apache.org/
11   https://www.mercurial-scm.org/
12   https://bitbucket.org/
13   TracSNAP can be found here: https://trac-hacks.org/wiki/TracSnapPlugin
14   https://trac.edgewall.org/

15   A video explanation of TracSNAP is available on YouTube here:
https://www.youtube.com/watch?v=FMQWur9A3DE

In the current version of the library, interactions and discussions are regarded as a linear thread, since GitHub does not use hierarchical discussion threads: therefore, each discussion is a single line of messages without any further branches to secondary lines of messages. Git and other platforms utilize hierarchical threads, therefore future versions of the library will have to consider such formats as well. The data gathered from Git and GitHub is formatted with a generalized simple structure, that can be used also for modelling interactions in other tools and platforms as well ().
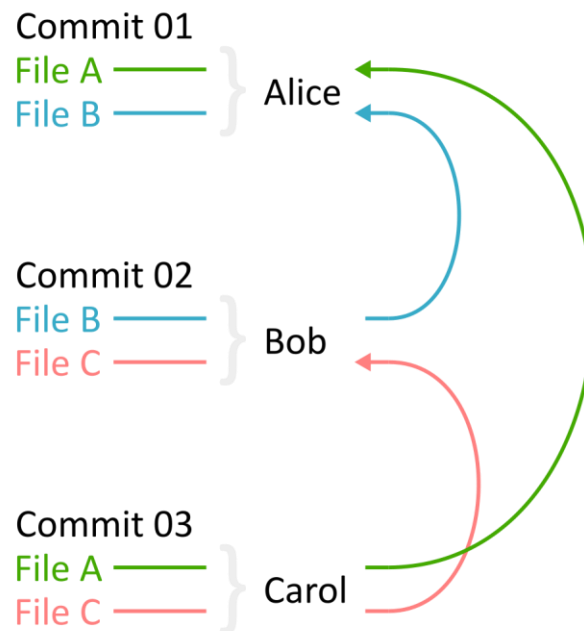
Figure 1.   The model adopted for extracting data regarding interactions among users from a Git project.
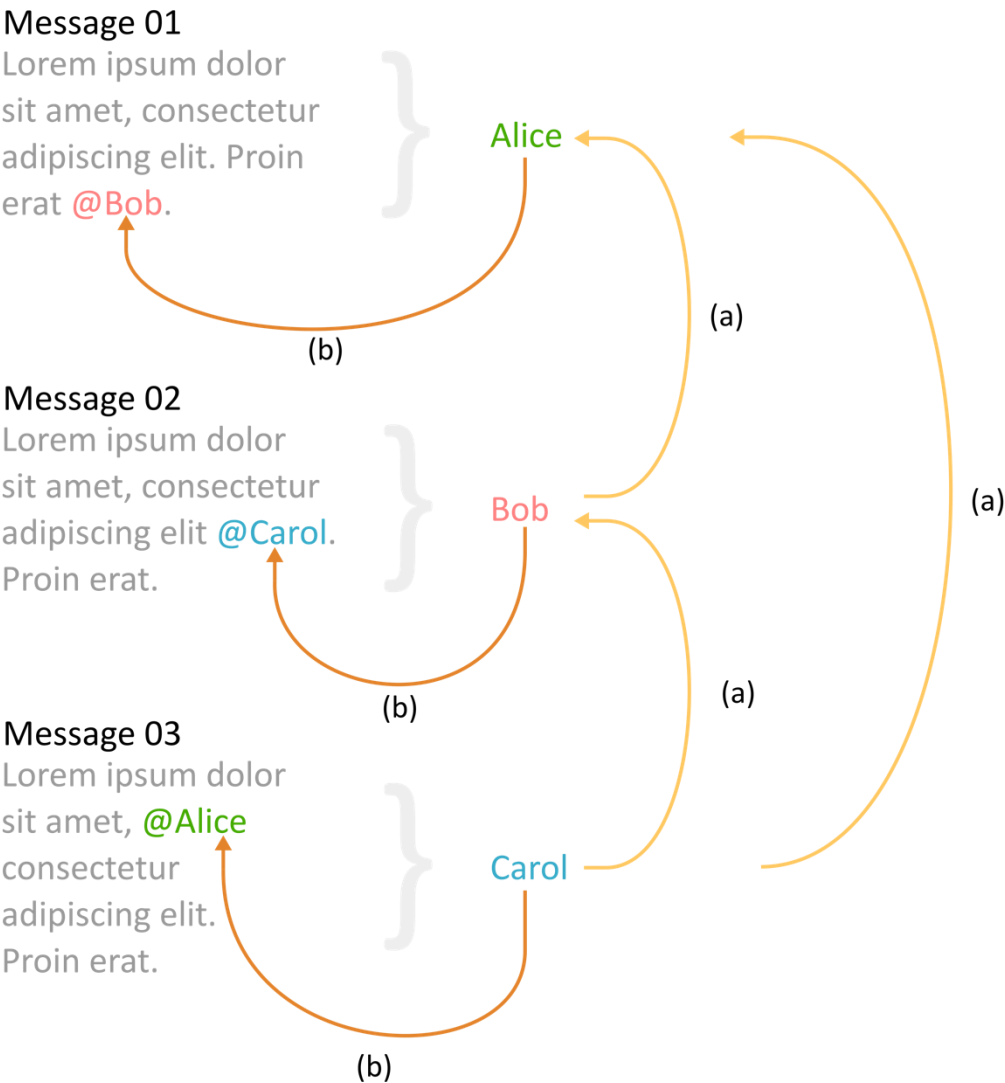
Figure 2. *The model adopted for extracting data regarding interactions among users from a GitHub project.*

Table 1. A simplified version in JSON format of the data that describes each action in a Git or GitHub project, from which interactions are reconstructed. Any activity from any tool or platform, if described with such format, could be used by the software library for extracting data regarding interactions among users.

```
[{
  "@node": "Content id",
  "date": "Content creation date",
  "msg": "Content title or body",
  "author": {
    "#text": "User name",
    "@email": "User e-mail",
    "avatar_url": "User avatar URL on GitHub"
  }
}]
```

3. Design, openness and platforms: three case studies

3.1 A data-driven approach for action research

The software library here proposed adopts quantitative methods for extracting data from social interactions over time in Git and GitHub projects. Since the library itself does not compute any analysis but instead focuses on extracting and formatting data, it could be used in different contexts and research approaches. For the sake of showing applications of the library and for further understanding how platforms influence makers and designers, especially within Open Design projects, this paper analyses three cases of design-related projects hosted on GitHub. Furthermore, these are cases in which the Author has participated: the library is then tested as a support for action research experiments where the Author acts as a reflective practitioner. The importance of releasing the library as open source lays in the fact that more researchers but also makers and designers could then use it with any project in order to understand their practice. The analysis of these cases might then advance our understanding of how platforms connects and influence makers and designers in their collaborative work on Open Design. The proposed software library generates enough data from which several analyses are possible, for example:

1. a graph of interactions among users (a social network analysis):
    1. centrality of users (degree, betweenness, closeness, eigenvector, …);
    2. users who produced commits, or just online comments;
    3. community structure;
2. a plot of interactions over time among users (a time series analysis):
    1. all interactions;
    2. interactions split by type;
    3. interactions split by user.

Only a subset of these options is adopted in each case in relation to the specific data.

3.2 Defining Open Design

Within the Free Software and Open Source movement, *definitions* are more important than manifestos, and this case tried to write collaboratively an Open Design definition in GitHub[16]. This project started in May 2012 and it is still active, with 71 participants and 72 interactions so far. The extracted data shows how the great majority of interactions has taken place as issue comments, and to a much lesser extent commits and forks: the project has hosted more discussion than writing (). Only 7.04% of participants created a commit, while 83.1% of them left an issue comment. The majority of users (64.78%) has no interaction, and two clusters form around the project itself (the interactions are technical operations) and especially in a group of users, where we can see that only some of them created a commit (). Most of the interactions took place in 2012 and 2013, with some recent interactions in 2016: interactions took place mostly in the first months of the project, and are starting again to take place, especially as issues comments (), by the most active user. At the moment the project seems to be declining and becoming the effort of mainly one user.

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16   The GitHub repository can be found at: https://github.com/OpenDesign-WorkingGroup/Open-Design-Definition
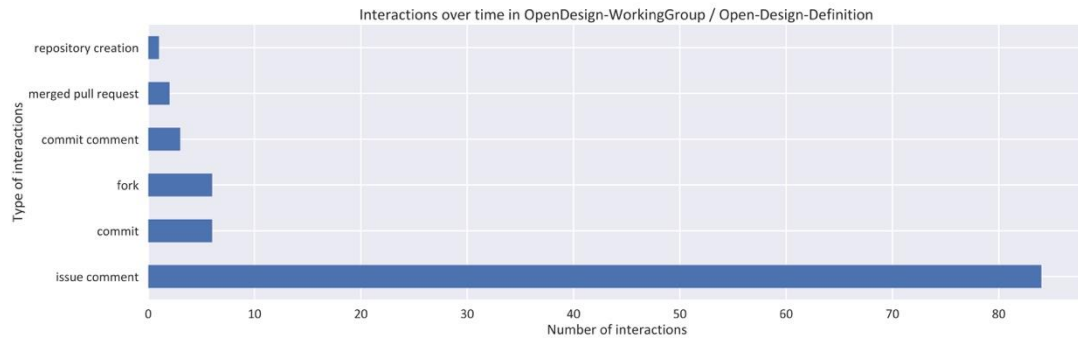
Figure 3.   Amount of interactions by type in the Open Design definition project.
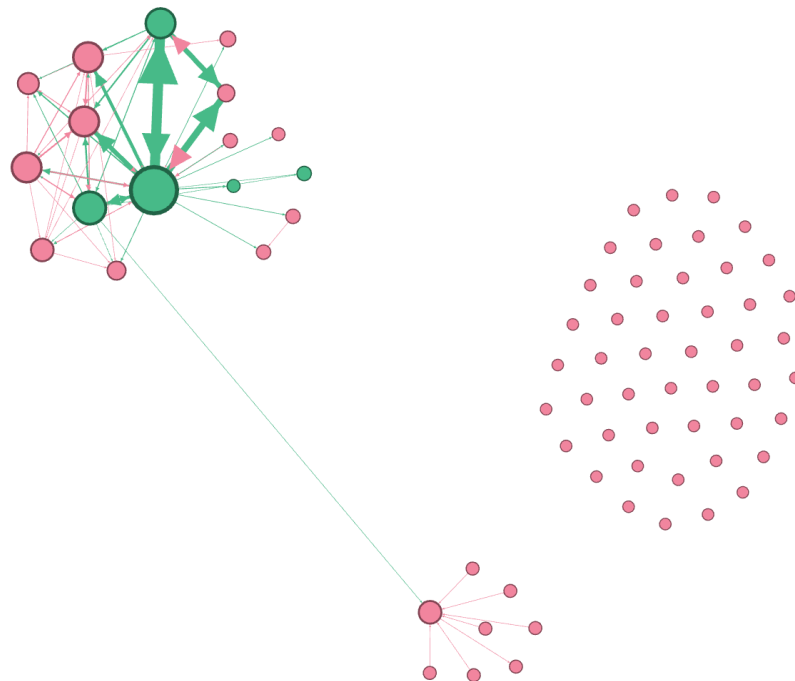

Figure 4.   Graph of the social interactions in the Open Design definition project. Green nodes interact in commits. The size of each node is proportional to its degree and the thickness of each edge is proportional to its weight.
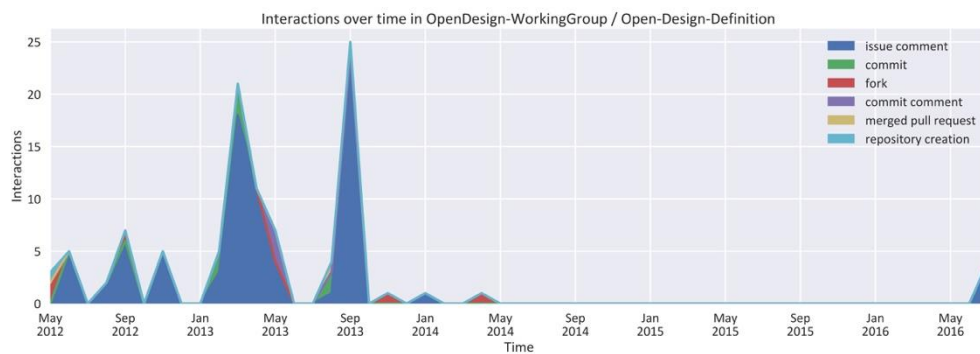

Figure 5.   Interactions over time in the Open Design definition project (resampled by month).

3.3 Teaching Open Design

The second case consists of a course about learning GitHub for Open Design projects, lectured twice within a Master in Interaction Design, in November-January 2013-14 (groups of 2 students) and 2014-15 (groups of 4 students)[17]. In this case, several projects were analysed together since the activity was split among multiple projects. As a whole, 34 users participated with 78 interactions. Here the great majority (91.17%) has at least one interaction, especially in commits and issue comments with almost equal intensity (). Here the graph of the interactions, coloured by the sub-communities identified (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008; Lambiotte, Delvenne, & Barahona, 2008), shows only 3 inactive users, some technical users and interactions, and especially all the students group connected to the lecturer as the main hub (). Two groups of two students interacted more with technical users than with the lecturer, becoming part of the technical users subgroup; two groups of 2 and 4 students instead become part of a single subgroup with the lecturer. One group of two students has most of the interactions, and one group of 4 students has much more interactions than the other: these are important outcomes taking into account that the purpose of the course was to experiment online collaboration. The time plot of interactions show bursts of activity instead of a continuous activity within the two courses, separated by several months of inactivity ().
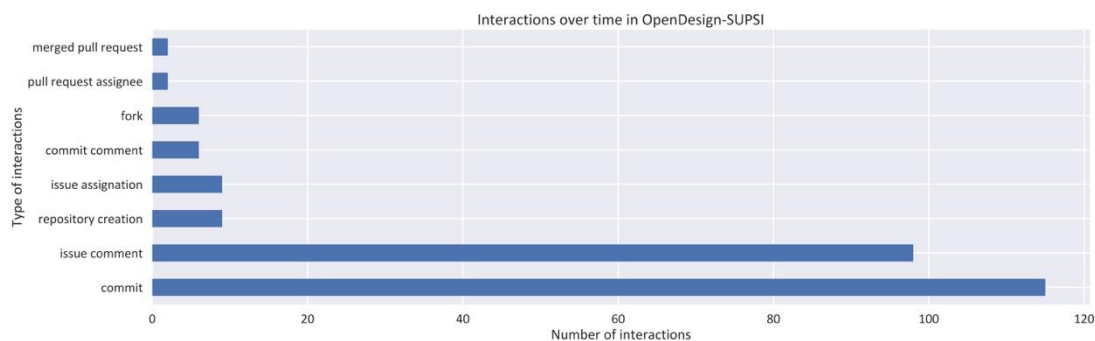

Figure 8.   Amount of interactions by type in the Open Design courses projects.

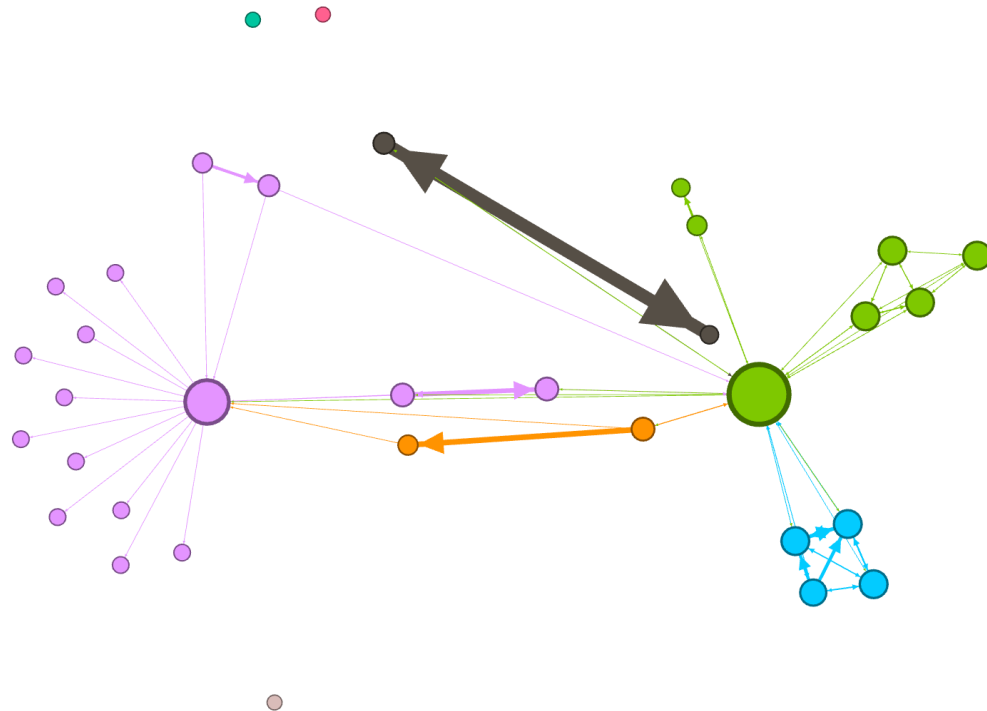17   The GitHub repositories can be found at: https://github.com/orgs/OpenDesign-SUPSI/

Figure 9.   Graph of the social interactions in the Open Design courses projects. The size of each node is proportional to its degree, the colour is based on the subgroups identified.
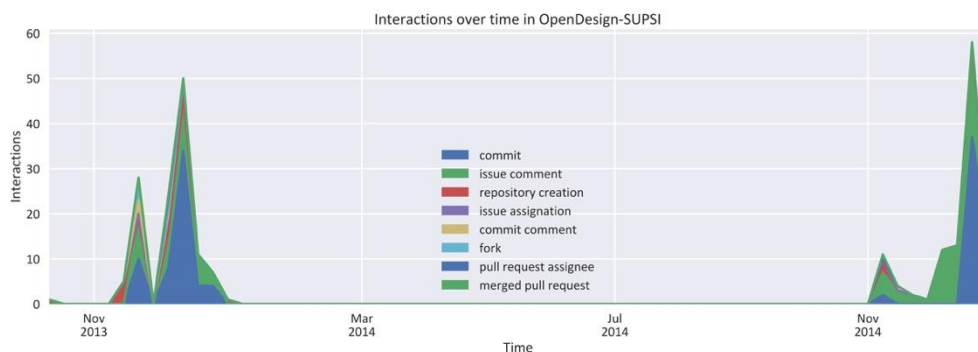

Figure 10.   Interactions over time in the Open Design courses projects (resampled by week).

3.4 Developing a Maker platform for Open Design projects

The third case is represented by a Maker platform, Fablabs.io[18], that connects the global Fab Lab network and that hosts Open Design projects[19]; even if the project hosting features are currently limited if compared to GitHub, it represents a platform that connect projects with people and laboratories, and therefore design with manufacturing. The project started at the end of 2013 and is still active nowadays, with 56 users and 74 interactions, but only 42.85% are active users, and the interactions are concentrated in one subgroup (). Here most of the interactions can be found in commits, almost the double of issue comments (). More specifically, the connections with most of

18   https://www.fablabs.io/
19   The GitHub repository can be found at: https://github.com/fablabbcn/fablabs

the interaction can be found with the main developers of the project (). Interactions however started only in 2015 and mainly with commits, and issue comments and assignation emerged slowly after that (): this could point to the fact that the initially the work was not collaborative, collaboration emerged later and increased with more discussion in the last months of 2016. This is probably the consequence of the change in the users activity, where the main active user stopped working in the second half of 2016 and two more users stepped in the project since then.
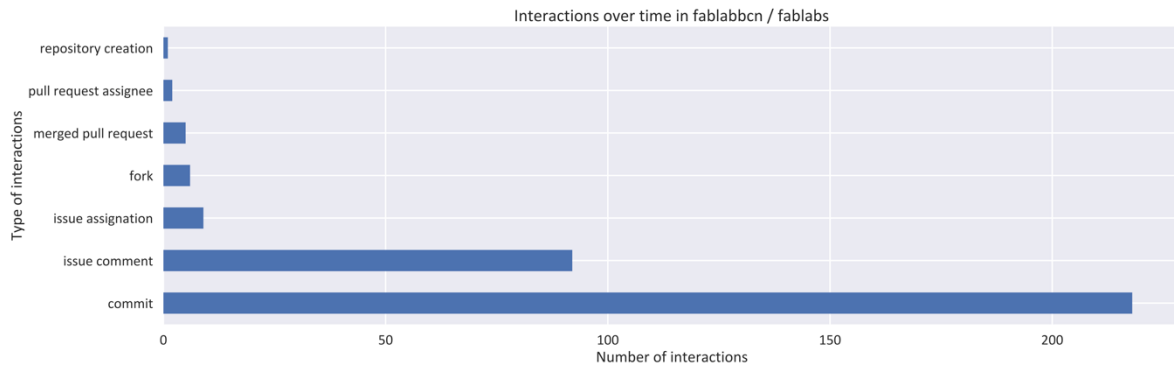

Figure 12.   Amount of interactions by type in the Maker platform project.
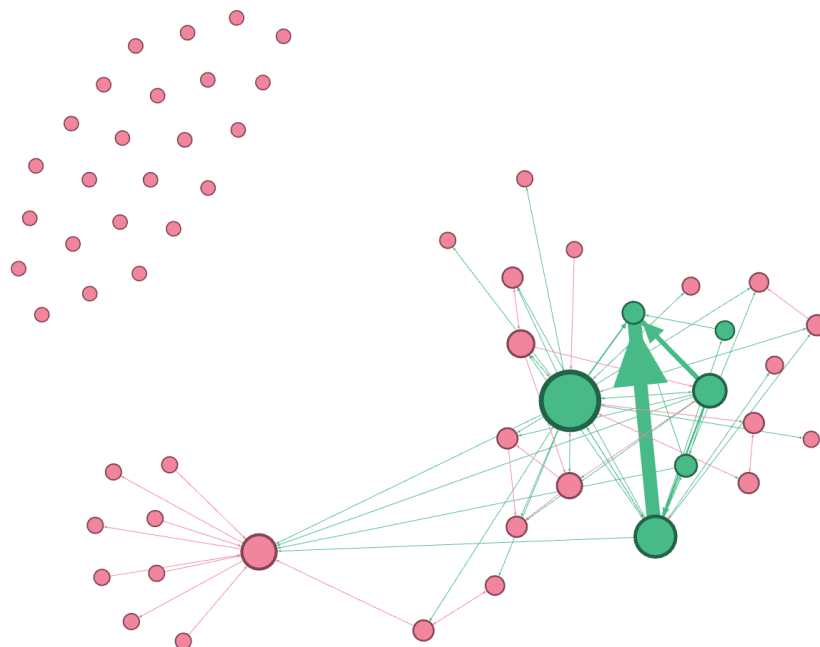

Figure 13.   Graph of the social interactions in the Maker platform project. Green nodes interact in commits. The size of each node is proportional to its degree and the thickness of each edge is proportional to its weight.
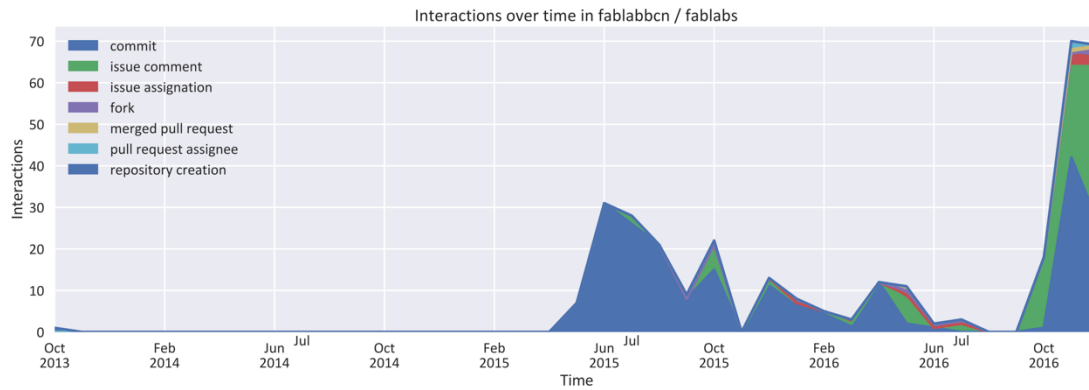
Figure 14. Interactions over time in the Maker platform project (resampled by month).

4. Conclusions

The increasing digitalization of content and activities might affect designers, especially thanks to their integration with the Maker movement, and it is therefore critical to start understanding the role of platforms in enabling projects and collaboration in them. This paper proposes a software library that extract data of interactions from Git and GitHub projects, a highly popular tool/platform ecosystem for software development that is also used for both Maker and Open Design projects. The software library was tested in three cases with similar size related to Open Design where the Author participated, in order to (1) advance our understanding of how platforms connects and influence makers and designers in their collaborative work on Open Design, (2) provide support to the activity of Maker and Design researcher and reflective practitioners. In the case of the Open Design definition (a)(3.2), the data shows how interactions took mainly place in the first two years but mostly on discussing the definition rather than on writing it, and with one main active user who is still active. In the case of teaching Open Design (b)(3.3), the data shows how differently the students worked together and when. In the case of the Maker platform that hosts Open Design projects (c)(3.4), the data shows how interactions started later in the project and how the development process has become increasingly more organized and structured, but still with a small core group. Overall, such analyses show that this approach is useful for understanding the process of a project, the interactions that constitute it, the kind of work done in it, the influence and importance of specific actors on it, and the amount of participation in it. Further research, especially at large scale, might uncover more insights about the impact of platforms on maker and designer activities, while research on single projects might uncover insights related to the specific projects. The software library proposed is able to extract enough data for several analyses, but this requires further analyses or custom interactive visualizations tools for exploring all the available data, which could be developed in further research. Git and GitHub are highly complex tools, and data extraction might be refined by following their development. This version of the library only shows interactions among users through time, these could be compared with the overall individual activity that is not collaborative, in order to understand the balance between autonomous work and collaboration. Furthermore, such library could be expanded to integrate more version control systems tools and social media platforms. Finally, the tool is mainly a quantitative one, and future research should combine it with qualitative methods like interviews, in order to understand not just the activity of a project as a whole, but also the experience of each participant.

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