

# Visual Dashboards in Trend Analytics to Observe Competitors and Leading Domain Experts

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**Abstract.** The rapid change due to digitalization challenge a variety of market players and force them to find strategies to be aware of developments in these markets, particularly those that impact their business. The main challenge is what a practical solution could look like and how technology can support market players in these trend observation tasks. The paper outlines therefore a technological solution to observe specific authors e.g. researchers who influence a certain market or engineers of competitors. In many branches both are well-known groups to market players and there is almost always the need of a technology that supports the topical observation. This paper focuses on the concept of how a visual dashboard could enable a market observation and how data must be processed for it and its prototypical implementation which enables an evaluation later. Furthermore, the definition of a principal technological analysis for innovation and technology management is created and is also an important contribution to the scientific community that specifically considers the technology perspective and its corresponding requirements.

**Keywords:** visual trend analysis, visual analytics, business intelligence, information exploration, innovation management

## 1 Introduction

Market trends are a major opportunity and risk in the ongoing digitalization of current markets. A variety of new players that are well known today, for instance Tesla, Uber Pop, Lieferando are still relatively new web giants like Amazon or Google, who have had huge success in establishing a successful digital business. Most of their technologies are used in our daily life. Many of those technologies are replacing or outpacing traditional businesses with the help of information technology and are making their usage easier and more comfortable. These new giants can benefit from the digitalization, as they have been making use of the opening opportunities. At the same time other giants fall because they fail to recognize these opportunities. And even more, they are unable to complete a sustainable digitalization strategy in time. The list of losing players, like AOL, Quelle, or Kodak, is long and it shows, how crucial trend observation in

a fast-changing world has become and how important it is to react to those trends timely and sustainably.

However, trend observation is quite a complex issue that requires experts with significant domain and technological knowledge. It also requires tools that support a periodical trend observation in a variety of data sources. Trends can be found in many data sources. To register them as an important upcoming topic, a considerable amount of data from a variety of sources is needed. In addition to data (sources) and expert users, there is also a third component that is essential to successfully identify trends: A technological solution to perform an appropriate data analysis in perspective of trends.

Therefore, this paper aims on introducing a new technical approach to observe trends in perspective of competitors and leading domain experts to enable an early trend recognition. Instead of starting the trend analysis from the topical point by direct searches or topical listings, what we already investigated [12], we propose a different approach by beginning the analysis with “the inventors” – so to say the persons behind developed new technologies. The idea aims more on monitoring certain groups of inventors instead on investigating principal new developments in general. This kind of monitoring is common in highly innovative fields or market niches with just very few competitors. The approaches oversee research and engineering actions of persons in form of authors and enable analysts to early identify new findings and developments that might be impacting the analyst’s business.

## 2 Foundations to Visual Trend Analytics

*Trend analysis* is a frequently used term in several domains, which makes it essential to define it more clearly to reach a common understanding. To find an access to the topic of visual trend analytics, we must first investigate the current state of the art of several closely related fields. A well-known area in which trend analytics is regularly performed is the banking industry, where market analysts try to predict future stock price movements based on temporal data [1]. However, in this paper we consider (Visual) Trend Analysis always in perspective of economic and market analysis [2].

In general, a *trend* is defined as “a method of identifying and describing specific changes over a long period of time, and the future can thus be predicted using past patterns” [3]. Complementary to this definition, *trend detection* can be defined as “Knowledge of emerging trends is particularly important to individuals and companies who are charged with monitoring a particular field or business. [...] Manual review of all the available data is simply not feasible. Human experts who are tasked with identifying emerging trends need to rely on automated systems as the amount of information available in digital form increases [4].” While trend detection is a relevant task within trend analysis, we follow the definition of trend *analysis* by Sharma et al. [6] where it is “a process of estimating gradual change in future events from past data”. Trend analysis is a quantitative method that requires precise specification of objectives that will be fulfilled from such investigation of data. The following list shows different goals,

presented by Chandler and Gray [6][7], that can be achieved by performing trend analysis:

- To describe the past behavior of a process.
- To try and understand the mechanisms behind observed changes.
- To make assessments of possible future scenarios, by extrapolating past changes into the future.
- To enable analysis of systems where long-term changes serve to obscure the aspects of real interest.
- Detect and estimate the magnitude of a trend.
- Identification of time periods in which there was a substantial trend and times in which there was negligible trend.
- To predict and forecast a trend.

## **2.1 Relevance of Trend Analytics in Innovation and Technology Management**

Nowadays, most innovations are not only a random side-effect of daily work. It can be described as a much more seriously organized procedure. Especially international companies have big research and development (R&D) departments, in which they follow a well-organized innovation process including a type of innovation center. In contrast to other departments, the R&D departments have a higher flexibility and less focus on the company's business. However, the intention in all their activities is to extend the company's products and services. For that purpose, the innovation center is building the bridge between research actions and normal departments.

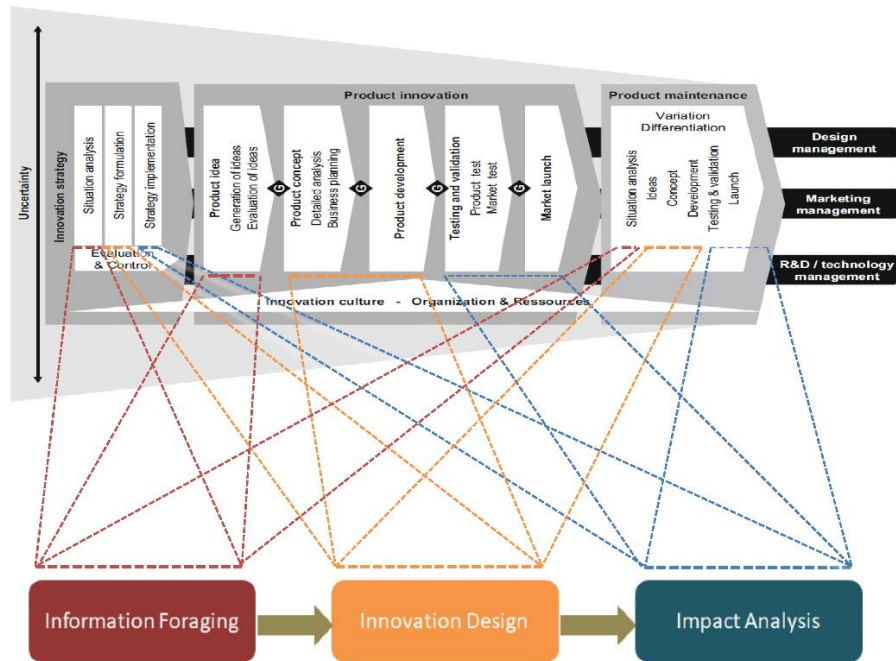
One of the more established innovation process models, which a variety of organizations have implemented, is the one of Gaubinger et al. (top model at Fig. 1). The process describes the innovation process in a tripartite process during which the uncertainty decreases. Each phase is subdivided into separate stages.

The first phase of the process is "innovation strategy" during which the situation is analyzed until a strategy can be formulated and implemented. The process is subject to steady evaluation and control and covers three stages.

In the second phase, called "product innovation", the general uncertainty has already decreased. Furthermore, due to the lower uncertainty the steps are more precise and cover a higher number of stages, namely five. It starts with the first stage in which the product ideas are generated and evaluated. Afterwards, a concrete product is conceived which involves a detailed analysis of the product and general business planning. After the conceptualization stage has come to an end, the product can be developed. Before the product is launched on the market, it should be tested to ensure the quality and the market's acceptance.

The last phase is the maintenance of the product. This phase is mostly a variation differentiation which might involve important security updates, new features, or simple design differences. Every variation goes through different stages before its launch, which are very similar to the second phase. Because of the similarity to the second phase, the number and stage objectives are similar, except for one additional to perform

the situation analysis, in which current product situation is analyzed and ideas for variations or rather advancements are gathered. Those ideas are conceived, developed, and tested before they are launched.



**Fig. 1.** The figure shows on top the innovation process by Gaubinger et al. [8] and on the bottom our simplified analysis model for performing visual trend analysis. The transformation and model reduction are sketched with the lines.

From a technical point of view, the entire innovation process can be supported with a suitable analysis software. Especially the research for existing approaches, algorithms or available technologies and systems can be supported and it is in principle in any phase almost similar. From the perspective of research systems, all three phases of the innovation process can be summarized into a three-stage model, which takes the main research objectives and goals into account (Fig. 1 shows on the bottom the three-stage innovation research model and covers also the transitions to the original innovation model above).

The first step includes the process of analyzing the current situation and developing ideas. As the first step mostly depends on the finding of information, we call it “information foraging”.

The second step involves creativity in choices for the innovative product. This includes creative new ideas and their conceptualization as well as their development. As this step involves creativity and design choices for the innovation, we call it “innovation design”.

The last step that can be identified is what comes after the product is developed, which mostly contains tests and validation phases. As it is about analyzing the impact of the product, we are going to call that phase “impact analysis”.

As the identified three phases are not static and include a lot of trial and error, the process and the identified phases are an iterative process, which may have to start over at any step.

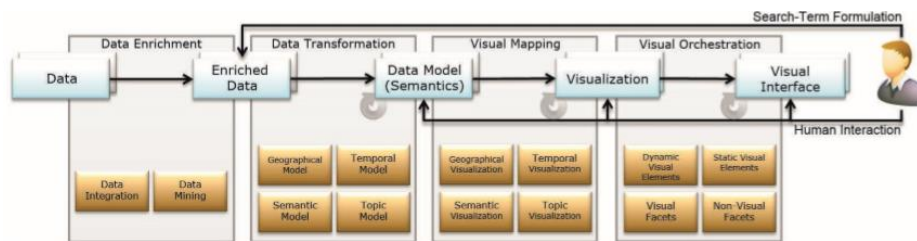
## 2.2 Visual Trend Analytics Methodology

An important aspect of Visual Trend Analytics is Visual Analytics, which is also the main interface functionality with which the user gets in contact. Keim et al. [9] describe visual analytics as: “[...] an iterative process that involves information gathering, data preprocessing, knowledge representation, interaction and decision making. The ultimate goal is to gain insight into the problem at hand which is described by vast amounts of scientific, forensic or business data from heterogeneous sources.”

Visual trend analysis combines trend analysis with the benefits of visual analytics.

Nazemi et al. [10, 12] describe their approach to visual trend analysis as a process which starts with the extraction and identification of key topics and their relevance, over a specific period, from scientific publications. The extracted information can be displayed in visual analysis tools which support users in the process of identifying trends and making decisions.

They developed an approach that utilizes the benefits of visual analytics to gather thus topic information and visually display the data inside several visualizations.



**Fig. 2.** Our Conceptual Model includes the five transformation steps: Data is enriched, structured, mapped to Visualizations, and orchestrated into a Visual Interface [10, p3].

The starting point of their approach lies in the formulation of a search term by a user. Depending on the search query, data is enriched and transformed into different data models. Those data models can be made for geographical, temporal, semantic or topic information. In a process of visual mapping the data is transformed and combined to be displayed in different visualizations which are orchestrated and displayed inside a visual user-interface. The interface enables user interactions on different levels. The user may change the data models used, the data displayed or interact with the visualizations.

With their approach they try to deliver a system to answer several key questions which are relevant when identifying technological trends.

They define these questions as the following [10]:

1. When did technologies or topics emerge and when did they establish?
2. Where are the key-players and key-locations?
3. Who are the key-players?
4. What are the core topics?
5. How will the technologies or topics probably evolve?
6. Which technologies or topics are relevant for a certain enterprise or application area?

### **3 Visual Dashboard Approach to Observe Trends of Researchers and Inventors**

In order to make objective decisions, decision-makers from various industries (e.g. the mobility, transportation and logistics domain [17]) need information about the behavior of the competition.

Abstract data gathered from text mining algorithms can contain such information about the competition, but neither has that data only quantitative measures that can be visualized nor is their dimensionality just two. They have far more different perspectives or aspects on data that could help to achieve the main goal of information visualization. There are different ways to visualize these data, e.g. by super-imposing visual variables or visualizations and by juxtaposing those into visualization dashboards [15, 16]. Commonly superimposing visualizations leads to overstraining users due to the complexity of the visual representations. Therefore, juxtaposing visualization as so-called dashboards or visualization dashboards leads to a more efficient interaction of the visualized data. But there are several ways to create such dashboards and different methods to ensure an easy interaction to meet the users' requirements [11].

#### **3.1 Visual Trend Analytics in Innovation Management**

The process of innovation management starts according to Gaubinger et al. [8] with the development of an innovation strategy. The first step when building such a strategy is an analysis of the current situation.

The information gathered in the process defined by Nazemi et al. [10] can assist in this process, by providing valuable information about technologies and the most relevant authors in different research areas. As the information comes in huge amounts of nested datasets, the data must be transformed into data models which can be visualized and orchestrated.

### 3.2 Data Processing for Dashboard Generation

There are several steps of data transformation applied before the data is ready to be displayed inside the different visualizations. As fundament we consider the already established data processing methodology in theory and practice as described and explained by Nazemi et al. [12].

At first, enriched data is gathered with the text mining algorithm LDA, which uses methods of unsupervised learning to convert collections of discrete data into topic models [14]. The data is indexed, so that it can be requested from a database.

As the data still has not reached its final form in which it can be displayed inside different visualizations, there are several relevant steps to undertake before doing so.

The first step is to convert the data into different data models, according to the transformational steps shown in figure 2. Data models for the topics, authors and the temporal development are needed.

Those models can be used and combined into visual structures. An example for the combination of the data structures is the process of receiving the name of a specific topic. As the topics are represented by numeric values which refer to a specific entry inside the topic data model, many models must be combined with the topic data model.

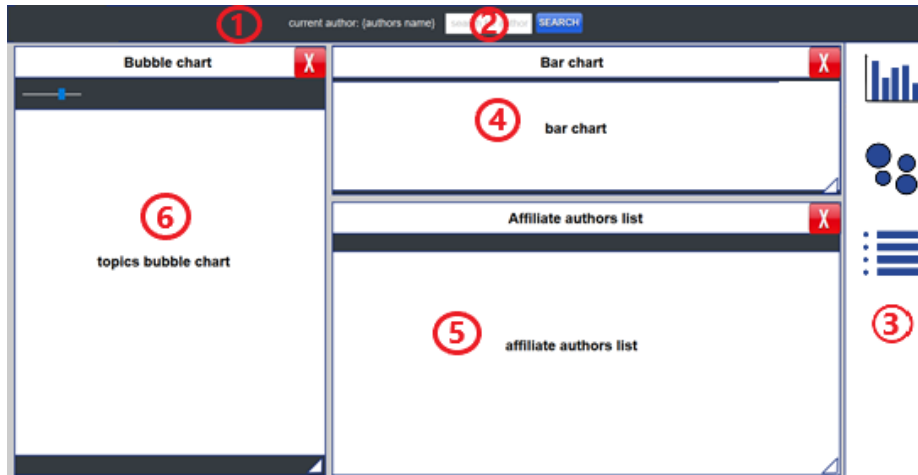
Before the final data can be displayed, data cleansing is necessary. Nonexistent values must be marked and displayed for completeness. For example, if there was a publication of an author without a publishing year, the value is set to 0 and will be displayed as the first bar in the bar chart.

### 3.3 Dashboard Design for Author Analysis

In the next section, we describe the developed analysis dashboard according to the different analysis stages, based on Shneiderman's Visual Information-Seeking Mantra [13].

#### Overview Phase

The overview phase provides basic information on an author's research behavior, the main topics of his publications and his co-authors.



**Fig. 3.** Wireframe initial view on the dashboard application.

Figure 2 shows the initial view on the dashboard application. (1) is the navigation bar at the top of the screen. It displays the current author, that means the author the dashboard is currently created for. It can be set initially to the most interesting author.

The next component to look at is the search field. The user may search for an author, by typing his name into the search field and clicking the search button. This will automatically change the name of the current author and it will also reload the entire dashboard.

Another navigation bar is (2) which is on the right side of the screen. The side navigation is displayed on the right side of the window. It contains several draggable components which the user must drag to the screen and drop, to display a new visualization.

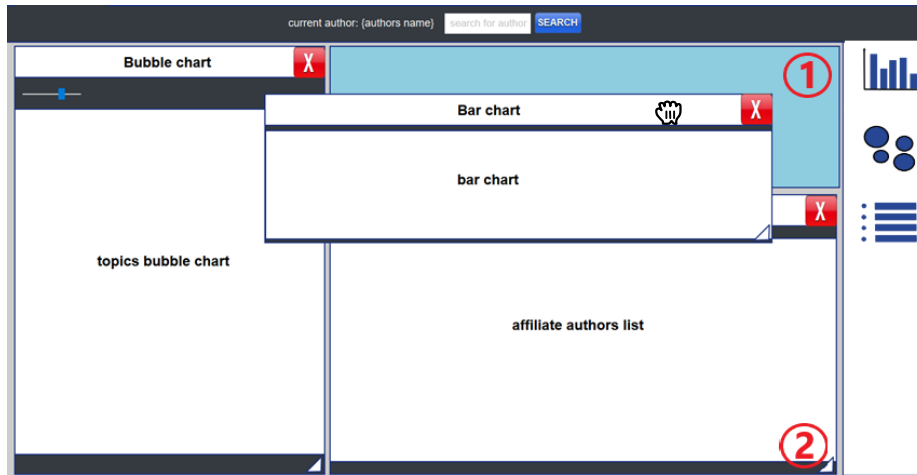
The dashboard which contains the charts (4)(5)(6) fills the rest of the screen.

The first visualization is a bar chart (4). The chart's y-axis indicates the amount of publications the searched author has published. The x-axis indicates the year in which he published the specific amount of publications. If there are publications with no year given, the x value is set to zero. The ticks on the y-axis mark the amount of publications in one year, starting from zero.

The list (5) displays the different co-authors of the searched author. The list is scrollable and displays the data in the format: first name, last name, amount. The amount depends on the number of publications they published together.

The bubble chart visualization (6) displays the main topics that the searched author explored in his publications. It has a slider to filter the main topics by their occurrence.





**Fig. 4.** Wireframe interactive behavior of the dashboard. Positioning and Resizing

Figure 4 shows the communication between the right navigation bar and the dashboard. As mentioned on the arrow the user may drag any visualization from the side navigation into the dashboard and drop it there. The dashboard shows the new visualization depending on which of the items the user dragged into it.

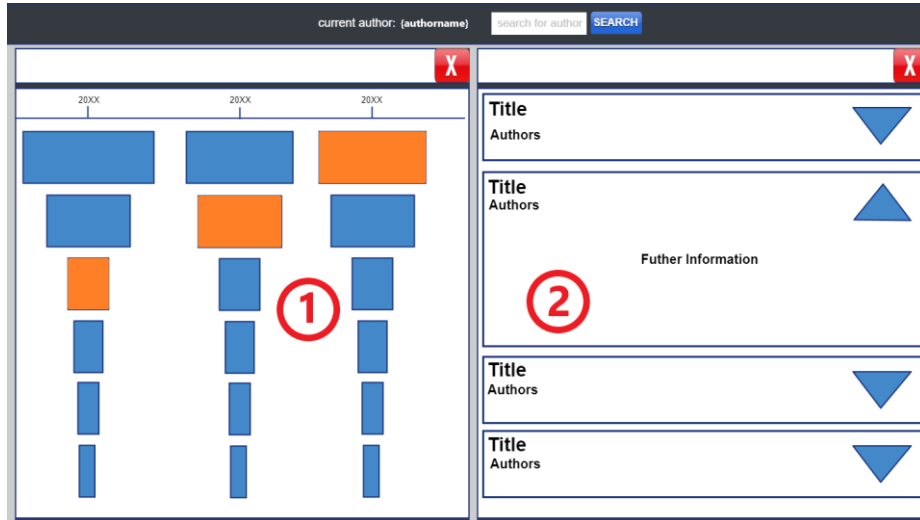
(1) The user can change the position of every visualization on the screen with drag and drop. The initial positioning of the visualizations is just a suggestion. The visualizations affected by the drag, because the dragged item is situated above them, are dodging to the next free position automatically. The dragged item has an on-hover effect. Marked in the dashboard by a blue shimmering underneath, as shown in figure 4. This is displaying where the visualization will be dropped on the screen.

(2) shows how to resize any visualization on the dashboard. Every visualization is inside a container which has a resize handler in the lower right corner. The user can resize the container and the visualizations resize too.<sup>1</sup>

#### **Analysis Phase (Data Zooming and Filtering)**

After gaining a first impression on an author's current research activity and the main research of his studies a more detailed view on the data can help investigate the work of an author. For tasks like those we provide a more detailed view on the data as shown in figure 5.

<sup>1</sup> There is a video of the first prototype of the system available on: <http://s.vis.h-da.de/video-vis-dashboard> (last accessed: 31/08/2020)



**Fig. 5.** Detail view on the dashboard application

(1) The first chart is not a typical chart. It shows the ranking of a specific facet like topics or authors displayed as slices of different width. The width refers to the amount in comparison to its neighbors. The vertical position refers to the ranking that facet has, as they are sorted descendant. The colors of the slices change when a user hovers and highlights the same facet over different years, making it easy to analyze the temporal development of a facet over the years.

(2) The second chart is a list view for specific publications by the author. It delivers information about the title and the involved authors. List items expand on click and display several other relevant pieces of information like the abstract of the publication, the main topics, and hyperlinks to the publications.

### Details Phase

A competitor analysis can require very specific knowledge of the work of an author. It is therefore necessary to provide as much details as possible. Figure 6 shows on the right side the view on one specific publication. It provides links to the full texts of the publications.

### 3.4 Prototypical Implementation

Figure 6 shows the prototypical implementation of the overview dashboard which is currently created for the author “Daniel A. Keim”. The implementation strictly sticks to the planning in the wireframes.

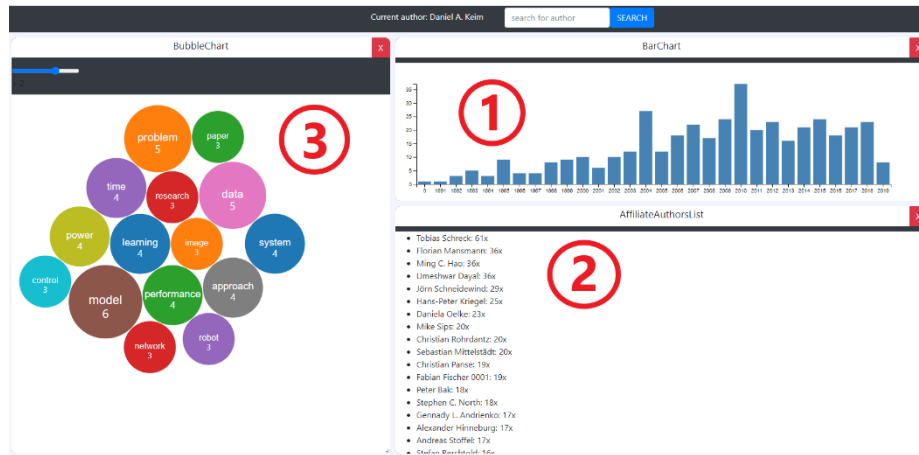


Fig. 6. An overview dashboard which was created for the author Daniel A. Keim

The prototypical implementation of the analysis and details phases can be viewed inside figure 7.

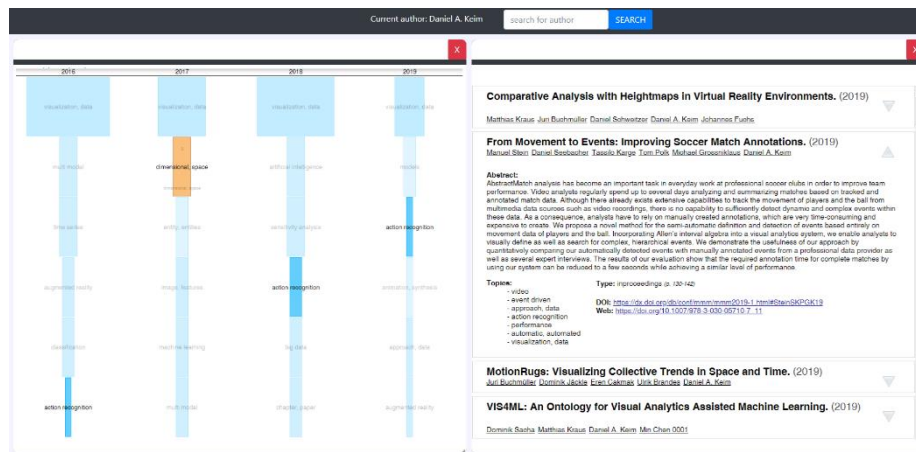


Fig. 7. A detail view dashboard for the author Daniel A. Keim

## 4 Use Case Competitor and Leading Domain Experts Observations

The application developed is an expert system which may deliver specific insights into the research work of competitors. For that reason, the general audience of the system is a small group of decision-makers.

To outline the benefit of our developed approach better, we will now write our description further based on the exemplary scenario. To be aware of all activities relating to your market, almost any leading actor is interested in a solution to observe research and developments of its field and particularly those of scientific influencers and competitors. So, they need a software system that allows them to identify the rest of the newly formed research team and they also need to clarify the main topics of their former and current re-search. Moreover, they must keep track of that research groups activities every month to investigate their current state of research.

### **Use Case Objective**

Let us imagine your role in a company is to be head of department toward visual analytics solution. In this position you want to be aware of any research activities in the field e.g. in form of news or research papers, especially those that are relevant for your market. Of course, you also want to know about any activities of you competitors. From the research field you will follow researchers in the R&D domain such as Daniel Keim. Similarly, you would do it with competitors.

### **Use Case Description**

In the first step an overview dashboard for the author Daniel Keim is created.

As one can see in figure 6, the overview dashboard provides different visualizations. This helps receiving different information about the searched author Daniel A. Keim.

The first information (1) delivers a temporal overview of the amount of publications over the last years. As one can see, Keim has been publishing significantly over the last years.

(2) provides an overview of his co-authors. The top co-author is Tobias Schreck. They have 61 publications together.

(3) provides a basic overview of the main topics of his publications.

As the overview dashboard - which is initially created - only delivers a basic overview, we need to dive deeper into the data to find out more about that author's work.

Figure 7 shows details about that author's publications. Chart (1) shows a ranking of the main topics for the last four years.

Chart (2) shows a list of the publications that author has published.

## **5 Conclusion**

All in all, one can say that metadata gathered by text mining algorithms (visualized, and juxtaposed inside visual layouts like dashboards), provides specific insights and knowledge into technological trends and people. This comes in handy in innovation management and competitor research. This is a specific need a lot of enterprises have. They need to be aware of changes in their market early and react to those changes fast in order not to fail the future customers' requirements.

The prototype developed in this paper tried to show a comprehensible use-case on how such a dashboard can be used to analyze a specific competitor. Even though it is

only a prototype it still presents a variety of benefits to observer market trends of specific persons. It is important to remind ourselves that for almost any market and business just a few influencing persons exist beside well-known competitors. This makes this approach so effective. It allows us to be aware of changes and new directions in a field by just observing a handful of people.

The future goal is to implement the dashboard functions for observations next to the already existing analysis solution for visual trend analytics to achieve an encompassing solution for trend analysis.

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