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Enabling Digital Co-Creation in Urban Planning and Development

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Abstract

Co-Creation is essential for urban planning. Online citizen participation is an established method to obtain feedback from citizens on a wide variety of plans. But tools and methods for digitized workshops are rare. The City of Hamburg and the HafenCity University develop a system, which integrates digital online and on-site participation. This paper reports on experiences and findings made during the development and testing of digital touch tables, peripherals and software. While touch tables proved to be powerful workshop-tools for the visualization of maps, plans, urban data und 3D Models, it also showed that the design of interfaces for the citizens' input is a challenge. Of high importance and high potential is the development of AI-based functionalities to support user input and feedback evaluation.

Keywords: Co-Creation, Urban Planning, Digital Participation, Artificial Intelligence, Natural Language Processing, Simulation, Data Visualization, Geographic Information Systems

1. Introduction

The participation of civil society in its development, the "co-creation" of the city, is a concept that has been intensively discussed in recent years in the international discourse on citizen participation [1-4]. Co-creation as a collaborative process supported by citizens and experts: “focuses on including relevant and sufficiently diverse knowledge in urban processes to create innovative solutions to complex problems” [5]. This participatory approach to steering municipal development processes represent a current form of urban governance, which assumes a strategic function in various EU programs and initiatives (EUROCITIES, EIP-SCC, Urban Agenda, Urban Innovative Actions) [6,7]. The aim of this strategy is on the one hand to link transformation processes back to the population, and on the other

hand to generate innovation impulses for urban development from civil society. A key role for the networking and interaction of the actors should be played by interoperable digital platforms that enable information-rich and rapid co-creation processes with many participants [8-10]. Falco et. al. identified 25 platforms globally which they define as "co-production"[1] platforms [11]. Within the last years, powerful commercial map-based softGIS applications like maptionnaire or citizenlab came into use [12, 13], which facilitate participation processes throughout the world. As well, methods and building blocks for such platforms have been developed in various collaborative research projects like Urban API [14], FUPOL [15], Smarticipate [16], U-Code [17], Civitas Digitalis [18]. However, the most successful open source solutions for citizen participation currently appear to be the similar [19] Consul [20] and Decidim [21] platforms of the cities Madrid and Barcelona, which are used on several continents and by millions of citizens.

This paper reports insights and experiences gained by institutions of the City of Hamburg in the development and piloting of their open source co-creation platform named "DIPAS" (Digital Participation System). After this first introduction and referencing we will second explain the derivation of the DIPAS project from previous projects, third outline the organizational and methodological setup of the project, fourth report on experiences and observations of the first field test, fifth describe approaches for the AI based analysis of citizens' contributions and sixth provide an outlook on subsequent development topics.

2. The Way to DIPAS

In order to expand participation in urban development, the City of Hamburg has established a novel staff unit in the State Ministry of Urban Development and Environment (BSW) in 2012. Together with the Hamburg State Agency for Geoinformation and Surveying (LGV), in 2016 this "Stadtwerkstatt" developed a map-based online participation tool for the City of Hamburg, to establish a regular online feedback channel in the cities' participation processes. The aim was to make municipal institutions independent of commercial software and to ensure full control over the information collected through discussion and participation procedures. The design of the online tool corresponds with the reference architecture for eParticipation software of the German IT Planning Council [22]. The tool has since then been used in over forty planning processes by various state ministries, district authorities and public development agencies [23]. In 2018 the BSW formed a joint project with the CityScienceLab of the HafenCity University (CSL)

[1] Falco's defines co-production as two-way interactions between the public sector and citizens that "go beyond basic information exchange to 'materialize' in policy measures, joint service delivery or other interventions" (Falco 2018:54) and thus uses the term quasi synonymously with the co-creation term used here.

and the LGV to further develop the online participation tool into a digital participation system (DIPAS). The new integrated system should include tools for digital participation on site using touch tables and clients for mobile devices as well as intelligent, AI-based evaluation functions [24]. This decision was based on the experiences made with the "finding places" project of Hamburg HafenCity University CityScienceLab, a cooperation with the MIT Media Labs's city science group. This participation process, which had the aim to find plots for refugee accommodation, proved successful. The benefit lied not so much in the identification of beforehand unknown building potentials but in the facilitation of an informed and reasonable discourse amongst citizens and experts about this highly polarized issue.

Over a time of three months more than two dozen workshops with in total 400 citizens were carried out in the CityScienceLab of the HafenCity University. A crucial factor in workshops was the possibility to visualize specific urban data about land use, planning law and ownership situation on the city scope tables [25]. This experience led to the idea, to develop a mobile system with similar abilities as the city scope tables, especially in regard of the visualization of urban data, for the widespread use in urban planning processes. The City Scopes of the MIT City Science Group allow the creation of complex urban models and the execution of complex simulations with these models. As Alonso et al. [26] point out, such data driven models are able to simulate the impacts of interventions on urban ecosystems and "as stakeholders collectively interact with the platform and understand the impact of proposed interventions in real-time, consensus building and optimization of goals can be achieved". Whereas the simulation abilities of these digital models are impressive, they are custom-made installations dedicated for the use in conventional workshop situations and have no online capacity or ability to digitally capture the user feedback. The methodological approach of DIPAS is to combine the online collection of citizens' feedback with the capacities of city scope like devices to enhance workshop discussions with the information resources of GIS and urban data platforms.

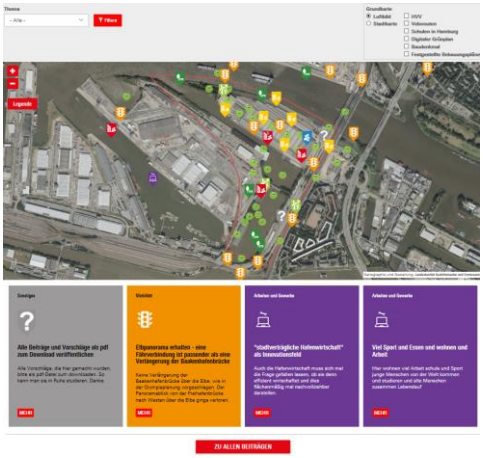


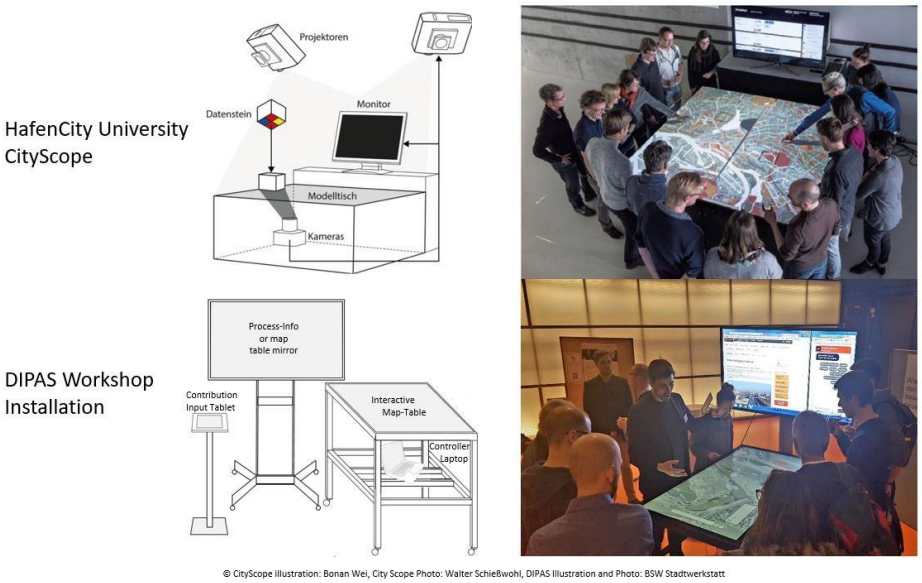
Fig. 1: Screenshot Hamburg Online Participation Tool

The development started with the map-based online participation tool

and the map-based CityScope planning tables, which the CSL adopted from the MIT [27]. For DIPAS the stationary City Scopes were replaced by mobile touch tables, which are operated via a specially developed frontend. Both applications work with maps, aerial photographs and geodata.

A fundamental requirement for the online participation tool is a comprehensible and reliable presentation and visualization of geospatial information [27]. Here, the urban data platform[2] comes into play, which integrates, connects and provides more than 3300 geospatial urban datasets as open data from various sources of the city via standardized and interoperable digital interfaces. Since 2014, the LGV has been developing and operating the master portal, an online web map application, which is the basis for data visualization in the online participation tool.

While the online participation method can be considered established, there are only few experiences for working with digital maps, 3D Models and Urban Data and a digitized feedback collection in planning workshops for the public. So a major task of the project was to develop and test methods for the integration of digital information and feedback into co-creative urban planning workshops.



© CityScope illustration: Bonan Wei, City Scope Photo: Walter Schießwohl, DIPAS Illustration and Photo: BSW Stadtwerkstatt

Fig. 2: Functional Scheme and Setting of HCU CityScope and DIPAS Workshop Installation

3. Iterative Development

The development of DIPAS was carried out in an iterative process with several development and piloting loops, in which the Stadtwerkstatt was responsible for the

[2] www.masterportal.org

technical control and organization of the pilots, the LGV carried out the software development and data integration and the CSL took over an accompanying formative evaluation and specific development tasks. Three development iterations with consecutive development goals were planned.
The concept was, to test every development stage in real planning processes, in order to receive feedback from appliers as well as from end users already during development. Up to now, a problem in the practice of cross-media participation processes is the media-break between the analogue feedback collected in workshops and feedback gathered online. During the "finding places" process information was presented digitally on the city scopes but feedback was collected with pen and paper. In the preparation phase of the DIPAS project it became evident, that in a system, which works with digital information-presentation and digital feedback-collection online, and digital information-presentation on-event, the collection of feedback in the events should not remain analogue. The primary concept was, to use the tables' surface as display and capture device. During the programming of the first iteration it became clear, that this was very difficult to achieve, as web applications by default have only one active window. So an active window for entering contributions would have set the map inactive, thus blocking all those in the group not writing a contribution from using the table. That meant, that contributions had to be entered on external peripherals using the interface of the existing online tool.
The prototype of the first development iteration was a 2D map and data touch table, operated by a designated "Desk-Jockey" and tablet computers as peripherals for the contribution input. Following the iterative approach, this basic configuration was sent to a first test and trial cycle. In the pilot deployment under live conditions, the system was operated as an add-on to the otherwise conventional workshop concept. This was due to the fact, that the workshops were part of real planning procedures and thus had to produce practically usable results with certainty, which cannot be guaranteed in an experimental application situation.

4. Usability Studies and Piloting

In this section, we describe the usability and user experience studies as well as the experiences from piloting DIPAS. The deployment of new systems in the real world frequently involves new hurdles and challenges. Regarding the usage of DIPAS in on-site workshops, these include the design of digitally facilitated workshop situations in a way that is understandable to the layperson and the comprehensibility and usability of the complex information and communication system.

4.1 First Development Stage

Following the iterative approach, the basic configuration was sent to a first test and trial cycle, consisting of the online participation tool, extra tablet computers for contribution input and 2D maps to be visualized on the touch tables, along with a designated *Desk-Jockey*, whose task is to supervise the interaction with the tables and to serve as a technical expert in their operation.

First Usability Study. To prepare the first live pilot, a usability study was undertaken in July 2018 to collect user feedback on the comprehensibility and handling of the clients and devices. The study comprised 25 participants, including both citizens activated by the City Workshop's newsletter as well as HCU students (cf. Figure 3). In groups of 5-7 persons, the participants tested the tables in three phases: (1) explanation of the basic table functions and the use case (conversion of the Grasbrook peninsula into a mixed use urban area) and retrieval of background information using the table functions, (2) input of contributions via laptop, tablet or smartphone, and (3) group discussion regarding remarkable features in the usage of the devices. For testing input of contributions onsite, the existing contribution mask of the online participation tool was used.

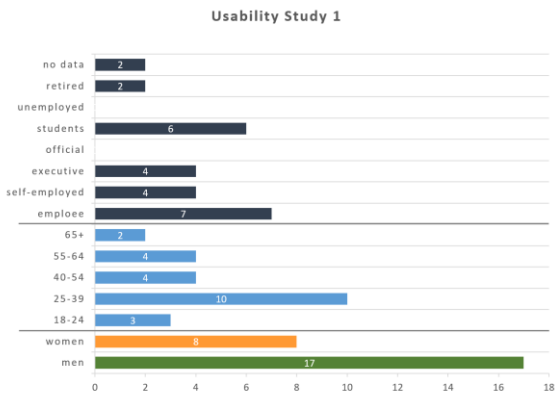


Fig.3: Participant Spectrum in First Usability and User Experience Study

Observation protocols and transcripts were categorized and analyzed with MaxQDA[3]. Amongst others, the results indicated that the majority of the participants appreciated the playfulness of the touch tables and stated a very good and quick information capacity. On the other hand, the study also revealed challenges for the next development steps: it became clear that the arrangement of the controls on the table and the design of the input device masks needed improvement.

Participants complained that areas of the input mask are not visible on the tablet and especially scrolling within the form is difficult. It also became apparent that

[3] https://www.maxqda.de/

the operators at the tables could not simultaneously operate the tables, moderate the group discussion and answer questions about the planning case[4].

First Pilot. On this basis, a pilot deployment under live conditions took place in August 2018: in the context of a public on-site event at the start of a strategic development concept for Hamburg-Bergedorf[5]. The aim was to observe how unprepared citizens react to the devices and to verify the planned moderation and workshop concept. The event attracted more than 200 citizens, of which 40 visited the two touch tables supplied. As a result of the usability study at each table now two experts, a table operator and a city planner, were on hand to answer questions from citizens. To prevent the experts from occupying the attractive south side of the maps and aerial photos, the view on the tables was rotated by 45° and the moderator was placed on the short side of the table, for which the control bar had made movable to all sides of the map. A first learning, was that, as soon as more than 8-10 participants gathered around the touch table, a second row formed. For these people it quickly became very difficult to follow the discussion right at the table, encouraging these people to either leave or start additional conversations [28]. The analysis of the observation and interviews conducted at this event confirmed the result of the usability study, that the design of the 'add-contributions' mask was perceived unhandy for touch devices like smartphones and tablets. This was despite the fact that additional slips of paper with QR codes were handed out, which could be used with smartphones to directly access the input mask of the participation tool. This insight gave the development of more intuitive input methods a high priority for the following development iterations.

4.2 Second Development Stage

Following the experiences of the first pilot of DIPAS, the Hamburg sub-project of Civitas Digitalis[6] focused on optimizing mobile input on face-to-face events [29]: while the ideation interface was originally designed for desktop use, nowadays, most users expect a responsive design for mobile devices by default. Thus, especially for face-to-face events, a more intuitive operation - such as the familiar interface of messenger services – was deemed to be a possible solution. Following the idea of an automated facilitation for the submission of contributions [30], a *wizard* like chatbot was conceptualized and implemented. This chatbot guides cit-

[4] Pohler N, Thoneick R (2018): DIPAS Evaluation Report 1, Auswertung der Usability und User Experience Studie sowie der Pilotierung von DIPAS in der Entwicklungsphase 1. Unpublished results, HCU CityScienceLab 2018

[5] See: https://www.hamburg.de/entwicklungskonzept/12144492/entwicklungskonzept-uebersicht/

[6] https://civitas-digitalis.informatik.uni-hamburg.de/

izens step by step through the process of entering contributions based on a structured conversation scheme, which leans on the form of the existing online participation. This scheme resulted in a mock-up and was transferred to a web client[7]

Fig.4: Design of the digital input facilitator chatbot

Second Usability Study. The second usability and user experience study with 24 invited test persons in three groups took place in April 2019 (Fig. 5). Object of the study was the 3D mode and extended functionalities of the table instance in the first upgrade stage. Another focus was on the contribution mask and the chatbot. The recruitment, setting, feedback collection and data analysis were comparable to the first usability study.

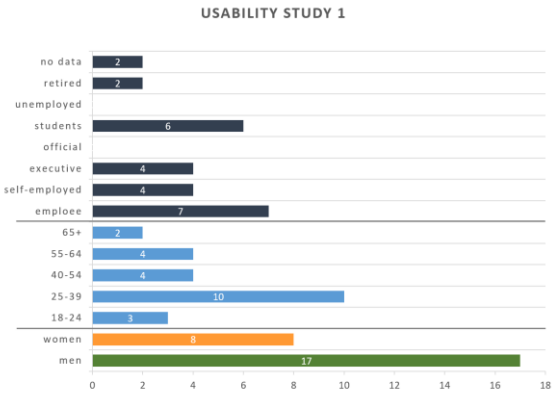


Fig.5: Participant Spectrum in second Usability and User Experience Study

In this study, the participants were invited to use either the devices provided or their own smartphones. The opportunity to use the chatbot and especially the intuitive communication were highly appreciated [8]. But the participants also mentioned, that the arrangement and designation of control elements could be

[7] available on https://civitasdigitalis.fortiss.org/

[8] Thoneick R et al. (2019): DIPAS Evaluation Report #2, Auswertung der Usability und User Experience Studie sowie der Pilotierung von DIPAS in der Entwicklungsphase 2. Unpublished results, HCU CityScienceLab 2019

improved as well as the sequence of contribution input and individual communication elements.

According to the participants' assessment, the map display was perceived as too small for input on the mobile phone, and should be displayed responsively over the entire screen. In addition to the point localization, the participants also wanted a functionality to draw lines and forms on the map. Some users suggested a back function in order to be able to make subsequent changes to their own text as well as a confirmation that their contribution had been received together with a link to retrieve it.

Second Pilot. The chatbot was first tested under live conditions in the participation process for the Grasbrook development area, which consisted of four coherent planning workshops from November 2018 to March 2019, each with more than 200 participants [31]. At each event, two digital DIPAS-workstations were deployed as an addition to four non-digital tables, each dedicated to a different topic, and the chatbot was actively promoted to participants: they could either enter contributions on provided devices (tablets and laptop) or using their own smartphone by scanning a provided QR code. The observations showed that many citizens expected to articulate their input directly at the touch table. To ensure the efficiency of the event, the moderators often took over the input of the contribution, using their smartphones to type in the citizens' contributions. Although this quick fix works, we do not consider it ideal as the text entered may be influenced by the moderator's point of view. In total, 158 contributions were received online, both during and after the workshops, of which 49 were created during the workshops using the participation assistant. The feedback regarding the chatbot was positive, but the number of contributions written by the participants themselves was comparably small. We see this as an indication, that the methods for digital contribution input must be further improved.

All participants suggestions gathered during the usability studies and the Pilots were taken into account in the revision of the chatbot and also in the redesign of the input procedure of the online participation tool, which now follows a step-by-step-sequence as well (Fig. 6).

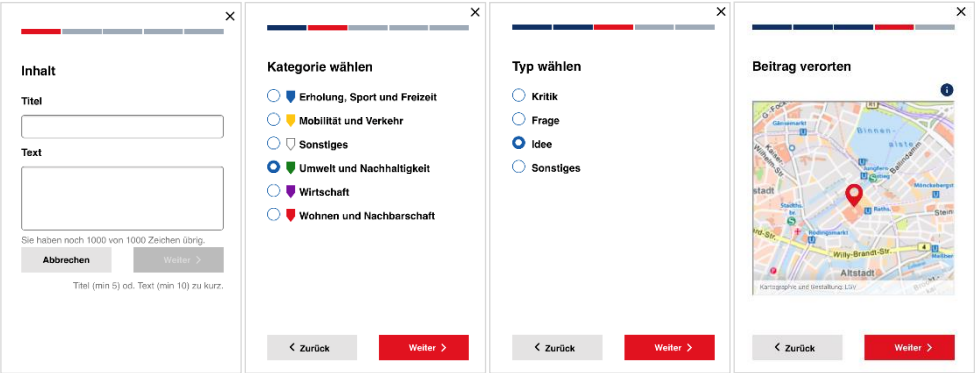


Fig.6: Redesigned interface of the online participation tool © Stadtwerkstatt

5. Optimizing Input and Output with NLP

This section covers two additional challenges that arise with the popularity of online participation: the accessibility and efficiency of contribution ideation as well as the evaluation of a large amount of complex and partly unstructured feedback. Regarding the ideation, both the online participation form and the chatbot require to specify a contribution with several features:

- title: A user-defined short summary of the contribution
- category: A thematic area to which the contribution can be allocated
- quality: choices are usually idea, advice and criticism
- location: User-defined location on map
- text: The actual unstructured contribution text

One of the findings from the usability studies was a perceived difficulty in this process - especially, a part of the collected contributions indicates a lack of congruence between title and text, which complicates their evaluation for the planners. Compared to analogue participation events, where the distinct ideas of the participants need to be georeferenced and digitized afterwards, the online submission stands for an immense simplification from the planner's perspective. However, especially with a significant increase in the number of submitted ideas, the requirements regarding the treatment of the collected information remain the same. It is necessary to thoroughly and systematically analyze and evaluate the generated feedback, to differentiate submissions by categories, to summarize contributions and to structure, prioritize and cluster ideas, and to develop a summary report. This requires expert resources, substantial effort and a high human capacity [27, 32, 33]. For both perspectives, the ideation process as well as the evaluation, we currently experiment with the application of advanced data processing techniques from artificial intelligence (AI) and machine learning (ML). In general, the field of AI can be

categorized into two broad fields: *symbolic* or rule-based approaches, which were the initial starting point for AI research in the 1950s. These rely mostly on a formal representation of knowledge, frequently related to a certain application domain, and logical interference based on that knowledge. In contrast *subsymbolic* approaches, of which nowadays the most widely used and probed methods are artificial neural networks. This biologically-inspired programming paradigm enables a computer to learn from observational data [32, 34]. Particularly relevant for the field of participation is natural language processing (NLP). Combining computer science and linguistic, NLP refers to the ability of a computer program to process, understand and even produce human language as it is spoken or written [32, 35].

5.1 The Citizens' Perspective: Ideation

We evaluated different means to enable a more accessible, easy and efficient participation for diverse groups of citizens by facilitating the ideation of contributions based on NLP methods. A first approach in this regard was realized by the development of the before mentioned chatbot, which is already capable to suggest keywords for individual contributions. This service has, so far, only been tested internally. Future developments could include the creation of a dedicated data model of terms specifically relevant for urban planning. In the current development stage, the chatbot follows a predefined scheme of questions. In upcoming developments, it could be equipped with the ability to recognize intents and entities in the user utterances to react more precisely [36, 37], for example to answer questions about the planning project. Additionally the chatbot could also intervene if a contribution is too short or too long, to not only structure ideas, but improve them on a content level [38]. Based on the identification of topics in the contribution text, it could also identify similar ideas and encourage users to merge them or to clearly distinguish their idea from others [18]. In summary, we see a great potential in the automated facilitation of contribution ideation. To further simplify the ideation process, we work towards a status in which the bare generation of a text describing the idea suffices to fill all other data fields, based on NLP methods. The automatic classification of ideas into a given set of thematic categories may equally be applied during ideation. Sentiment analysis methods could give an estimation of the quality, indicating the contributor's attitude towards the planning. An approximate geolocation or area could be extracted from the contribution text based on a matching with streets and places from the area under consideration.

To unburden users from having to evaluate which ideas to put into the title and which to exemplify in the text, we evaluated and compared two algorithms to automatically generate a title for a contribution text. It has to summarize the contribution precisely while still providing meaningful information for other users. For

the planner, automatic title generation and summarization could increase the comparability of contributions. In fact, text summarization is an important research area of NLP. The goal is to express the content of a document in a condensed form while containing as many key aspects as possible under a given length limit [35, 39]. Two different approaches are common for text summarization: extractive and abstractive methods. While extractive approaches identify and combine the most meaningful text segments based on statistical features, abstractive approaches rely on subsymbolic AI and employ neural networks to generate a summary based on a semantic representation of a document [35, 40]. On this basis, we implemented a combinational approach, which concatenates verbal indicators of the mentioned location (street, place or district name) with the most meaningful text segment based on TF-IDF (term frequency – inverse document frequency) [41] and part-of-speech-tagging. Then we compared the results to the outcomes of an abstractive approach based on GloVe word embeddings and encoder-decoder methods. As the data corpus was comparatively small, with a total of 3096 contributions, we additionally trained the abstractive model with the German news dataset[9].

For an evaluation of the generated headlines, we employed ROUGE-1. This recall-oriented metric, one of the most widely-used evaluation metrics in text summarization, measures similarities between system-generated and human-written reference summaries [42]. To combine recall and precision, we employ the F1-Score: while the abstractive summarizes exhibit a significant overfitting to news keywords, the combinational approach resulted in a F1-Score of 17.34%, compared to a F1-Score of the original headline of 27.31% [43].

Text	Optimal Headline	Generated Headline
Die Brücke gehört abgerissen und durch eine ebenerdige Querung ersetzt, die für alle Menschen nutzbar ist. Fußgänger auf Brücken und in Tunnel zu verlagern, ist eine städtebauliche Unterwerfungs-maßnahme des vergangenen Jahrhunderts.	Brücke abreißen	Brücke ersetzen
Das Anwohnerparken sollteauch in Ovelgönne sichergestellt werden¨	Anwohnerparken in Ovelgönne¨	Ovelgönne: Anwohnerparken sicher-stellen

[9] https://webhose.io/free-datasets/german-news-articles/

Der Tunnel im Bergedorfer S -Bahnhofs sollte verschönert werden. Auch die Lohbrügger Seite des Bahnhofs ist verfallen und oft dreckig.	Verschönerung von Tunnel und Lohbrügger Seite im Bergedorfer S-Bahnhof	Bahnhof verschönern

Table 1: Sample Headlines based on the combinational summarization approach

These scores may seem not very high, but the generated headlines have shown to be sufficiently informative for upcoming studies or pilots in live environments (Table 1). Upcoming developments of DIPAS could include this feature and support the evaluation at the same time: as the system suggests a title while still offering the user to manually edit it. An evaluation of the title acceptance and edit rates will help to evaluate and improve the summarization service. To assess the effectiveness of these methods regarding the idea of encouraging more citizens from diverse backgrounds to participate, methods from the research area language style matching could potentially allow to draw conclusions, based on the contribution texts, about the distribution of demographic attributes among the participants.

5.2 The Planner's Perspective: Evaluation

As much as NLP-methods may facilitate the ideation of contributions, they are also applicable to improve the following evaluation. Here, the sentiment analysis could go beyond the estimation of the quality of the contribution, and the summarization could help to provide a first overview of the main aspects of the contributions. For the evaluation, additional features are available for each contribution, including the timestamp of submission, the amount of comments and ratings and the average rating. This widens the space for possible analytics and ML approaches. A very current and relevant problem in the evaluation is already tackled with classification methods. The planners are allowed to create their own new categories for their participation processes, to which the citizens associate their contributions. Having conducted nearly forty digitally supported participation processes with a large variety of topics, it has become very difficult to compare contributions across processes. Thus, Balta et al. first tested an approach to automatically classify contributions based on manually categorized data from nine planning processes [32]. The results show that the sample size of the respective class is essential for the accuracy. The classification algorithm reached an F-Score of 83.69% for the largest class of contributions, transport and mobility. With an extended classification, which also suggests the second- and third best category, it was possible to achieve an accuracy of more than 90% [ibid].

For future developments, we see even more possibilities by the use of NLP in the process of data evaluation. For instance, a current problem in the evaluation is the order of contributions: a relevance score could help to pre-organize the amount of

submissions and to recognize, filter and pre-select the most relevant and high-potential ideas. These could be identified based on a significant amount of informative content, a high response from other users and certain degree of mutuality with the topics other users referred to. Furthermore, a special asset in the contribution data is the induced connection between a geographic location and the textual expression of ideas, opinions and impressions about it. In the context of mining location specifications, this could be used to identify areas of high importance for a large amount of citizens; which could accordingly encourage the planners to pay a dedicated attention to those in the urban design process.

6. Conclusion and Outlook

Overall, the recent developments in the DIPAS project and the practical experiences and insights which we gained in the usability studies and test deployments showed that digital participation platforms have a lot of potential for increasing the reach and depth of participation processes - paving the way towards actual co-creation. For these to be opened up, both, competitive applications for the end user as well as support for professional users in dealing with the amount of information are necessary. AI functions could be the key to faster and better information processing. Regarding the elimination of the media break between on-site and online participation, we have seen that touch tables are powerful tools for digital workshops, but also that the provision of mobile tools does not automatically lead to higher or better participation. Here further work on workshops designs and seamless capturing tools is necessary.

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