D-WISE Tool Suite for the Sociology of Knowledge Approach to Discourse

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Abstract. Under the umbrella of the D-WISE project, manual and digital approaches to discourse analysis are combined to develop a prototypical working environment for digital qualitative discourse analysis. This new qualitative data analysis tool, called D-WISE Tool Suite, is built up in a process of close exchange by the two teams from humanities and informatics and focuses on developing central innovations regarding the availability of relevant Digital Humanities (DH) applications. Bridging the gap between structural patterns detected with digital methods and interpretative processes of human meaning making is at the core of the collaborative approach of anthropological studies and computer linguistics in the D-WISE project, which innovates both informatics technology of context-oriented embedding representations and hermeneutic methodologies for discourse analysis in the Sociology of Knowledge Approach to Discourse (SKAD). In this paper, the intertwining of the two paradigms Human-in-the-loop and AI-in-the-loop will be presented by outlining the concept of Human Computer Interaction (HCI) in the D-WISE Tool Suite with its AI-empowered features and established modes of feedback-loops and the supported functions for facilitating SKAD.

Keywords: Human Computer Interaction · Discourse analysis · Human-in-the-loop · AI-in-the-loop · User stories

1 Introduction

The research project D-WISE is a close collaboration of an interdisciplinary team of researchers with the humanities represented by the Institute of Anthropological Studies in Culture and History and Information Technologies represented by the Language Technology Group at the Department of Informatics at the University of Hamburg. Started in May 2021, the project aims to develop central innovations to address challenges researchers are facing with regard to methodological approaches from Digital Humanities (DH) and discourse analysis and the increasing dealing with open corpora,

consisting of heterogeneous, multimodal, and big data. To address these goals, under the umbrella of the D-WISE project, manual and digital approaches to discourse analysis are combined to develop a prototypical working environment for digital qualitative discourse analysis. This new qualitative data analysis tool, called D-WISE Tool Suite, is built up in a process of close exchange by the two teams from the humanities and informatics and focuses on developing central innovations regarding the availability of relevant DH applications. For improved modelling of the plurality of meaning and the integrated processing of multimodal data, contextualized embeddings are developed to expand the existing range of DH methods and support and enhance the research process via artificial intelligence (AI) supported functionalities and semi-automated processes. In a constant combination of manual analyses by human agents and its provided feedback loops, digital automated functions are simultaneously developed to the needs of the human scientists and the detected shortcomings in comparative critical analyses of existing tools. This methodological approach, called user stories, enable a constant exchange and trouble-free interdisciplinary collaboration, as well as reflexive, hermeneutic processes, and documentation of the discourse analysis. This interactive working mode manifested in the development of the D-WISE Tool Suite will be presented here as a methodological approach to combine manual and digital analytical methods in qualitative and quantitative social and cultural research facilitating also the epistemological reflection on relevance and validity of the gathered data and the hermeneutic processes. Therefore, while the approach focuses in a first step traditionally on Human-in-the-loop, in a later step AI-in-the-loop will be brought into focus again to support the user and the process of discourse analysis with digital solutions, algorithms, and AI. Originated directly in the research process, this circulation of agency in human and computer interaction and the mutual backing, the enhancement of technical functionalities, and training abilities of the AI by humans, as well as the improvement of qualitative research processes of the humans by the AI-supported digital work environment, lays ground for a new approach of reciprocal influence, enhancement, and reflective processes.

For this paper, the intertwining of the two paradigms Human-in-the-loop and AI-in-the-loop will be presented by outlining the concept of Human Computer Interaction (HCI) in the D-WISE Tool Suite with its AI-empowered features and diverse modes of feedback-loops and the supported functions for facilitating the methodological approach of the Sociology of Knowledge Approach to Discourse Analysis (SKAD) (Keller et al. 2018). The alignment of this methodological and technical innovation is based on the epistemological principles of Grounded Theory (GT) as a methodology for reducing the fast complexity of social settings in hermeneutic research and advances in informatics. Powered by state-of-the-art NLP models (natural language processing models), the D-WISE Tool Suite is designed with multimodal media as its core. AI-in-the-loop is considered a core principle when developing features, to allow for a novel AI-aided hermeneutic process where humans and machines benefit and learn from each other.

2 Project Overview

The D-WISE project aims to address the lack of digital solutions for multimodal discourse analyses with the capacity to cope with the multimodality of materials, the plurality and ambiguity of meanings, which all provide multiple challenges and complexities

for digital solutions. Seeking to bridge the gap between structural patterns detected through digital methods and interpretative processes of human meaning making is at the heart of the collaborative approach of anthropological studies and computer linguistics in the project, which innovates both informatics technology of context-oriented embedding representations and hermeneutic methodologies for discourse analysis in SKAD. The D-WISE approach centers human-algorithm interactions, to improve AI research systems, which have an impact on the human research process and outcome. At the same time, SKAD addresses the challenge of coping with an ever-increasing number of digital materials on the Internet and beyond by enhancing the methodology through digital methods.

The epistemological reflection and further development of hermeneutic methodology in the use of semi-automated procedures is an integral part of the projects' elaboration on how automation can be usefully integrated into qualitative discourse-analytical approaches. Relevant tools for automated analyses are made available in a newly developed work environment that focuses methodologically on the SKAD discourse analytical approach and form a heterogeneous and multimodal material basis from different research contexts of the humanities. In the course of the project, the range of methods will be broadened by developing contextualized embeddings for improved modeling of meaning plurality and integrated processing of multimodal data. Methodological and technical innovations and reflection, combined with discourse analysis and GT as a hermeneutic methodology are aligned through constant and close collaborative exchange between the two teams from cultural anthropology and language technology.

2.1 Augmenting Capabilities: Of Humans and AI in the Loop

A major interest of the project is to contribute to a human-centered approach, which is a sign in AI development becoming stronger (Li and Hilliges 2021)[1]. In the center of this development, key questions are how humans and AI interact and in which way does this interaction aid human needs. One of the crucial places where this issue resides and the question determines if AI approaches are human-centered is "the loop," a most important component of learning systems. Loops are implemented for providing feedback, hence they are essential for learning by giving opportunity to correct, improve, and evaluate results in AI, as well as for human learning, for developing further information technologies and for humanities research.

Human-in-the-Loop. The Human-in-the-loop paradigm is closely linked to the concept of Interactive Machine Learning (IML), which can be defined as "algorithms that can interact with agents and can optimize their learnings behavior through these interactions, where the agents can also be human" (Holzinger 2016, p. 119). Even though interactions with both computational and human agents are important for optimizing the learning behavior of machines, it is mostly human expertise and the heuristic selections made through these interactions that supports automated processes. This is crucial in solving computational problems by giving feedback, through which the creation of training

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[1] Li and Hilliges (2021, vi) point this out in their introduction with reference to the foundation of new institutes in Stanford, Maryland, Utrecht and the Technical University in Denmark.

materials for learning and occasionally for the development of so-called Gold Standard materials takes place. While most algorithm-in-the-loop settings still rely on a human decision maker to interpret and incorporate information, prioritizing the human's decision over the algorithms are processed as the most important outcome (Green and Chen 2019, p. 9). However, giving feedback to learning AI systems is mostly a repetitive, boring, and often unpaid task for human minds; solving Captchas queries for training image recognition, monitoring tags of automated annotations or automatically selected patterns to feed the data hunger of AI systems and give important feedback to the machine, offer but hardly any benefit for people performing these tasks. At best, the benefits for humans in human-in the-loop approaches come indirectly (Krishna et al. 2021) or in a figurative sense of efficiently working AI systems. However, the Human-in-the-loop paradigm is not synonymous with human-centered AI as we can observe through the example of the autonomous vehicle; in real-life situations bringing humans-**out**-of-the-loop is essential for saving lives, even though a very challenging undertaking (Holzinger 2016, p. 120).

AI-in-the-Loop. The second way of organizing feedback for learning puts AI-systems in the loop of human learning and thus shifts human-machine-interaction towards a paradigm of hybrid intelligent systems. "We define hybrid intelligence (HI) as the combination of human and machine intelligence, augmenting human intellect, and capabilities instead of replacing them and achieving goals that were unreachable by either humans or machines" (Akata et al. 2020, p. 18). Including AI-in-the-loop for giving feedback to human research and knowledge production alongside the established Human-in-the-loop paradigm, we get a hybrid knowledge system by organizing iterative feedback processes, which allow for mutual benefit for both humans and AI systems (Oeste-Reiß et al. 2021) (Fig. 1).
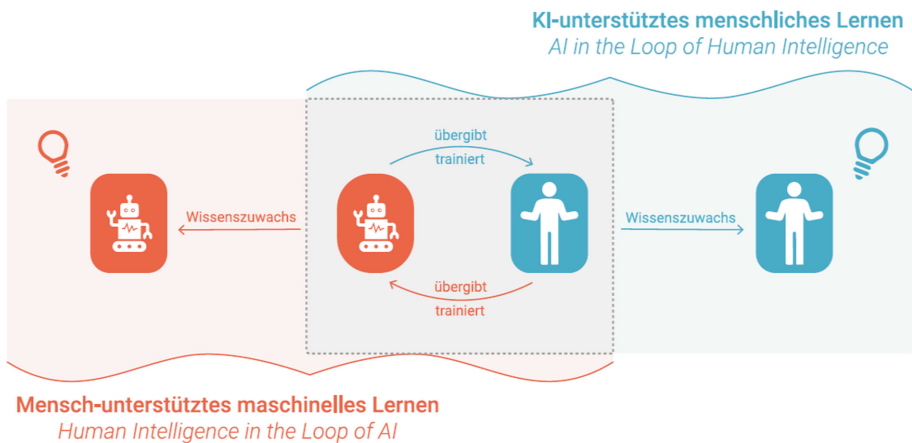

Fig. 1. Hybrid knowledge production system; Source: Oeste-Reiß et al. 2021, 149.

2.2 Prototype

The D-WISE Tool Suite is currently implemented as a web-based server architecture on the basis of already successfully established DH methods and the parallel processing by researchers from humanities and informatics, and will be accessible in open access. As a web-based annotation tool with machine learning components, the D-WISE Tool Suite offers a process that is "interactive, as it suggests annotations that can be accepted, rejected or corrected by the annotator, whereby machine learning gets better in time" (Yimam et al. 2017). The Tool Suite supports all SKAD steps – from the specification of the research phenomenon to the evaluation and its documentation. This research process is technically developed as a cyclic process, adaptable, and reusable, therefore corresponding to a hermeneutic circle, which, with repeated questioning and constant expansion of the state of knowledge, leads in repeat to new questions, insights, and, as a consequence, to a deeper understanding of the phenomenon.

As a prototype, the D-WISE Tool Suite will initially be implemented with a SKAD of current discourses on digitization in the healthcare sector and the associated data protection issues. The discourses in the course of new legal regulations will be examined with regard to the actors and groups of actors involved, in particular patients, physicians, clinics, health insurance companies, companies, interest groups, and politics. For this purpose, represented discourse positions will be analyzed on the basis of information available online and supplementary ethnographically collected data. Based on this, the usability of the D-WISE Tool Suite for scientists from different disciplines will be evaluated and further developed within the framework of a fellow program.

2.3 Digital Tools and Hermeneutics in SKAD

Digital tools for organizing and annotating research data, such as Excel in the simplest form, or data analysis programs such as MaxQDA Atlas.ti, NVivo, or CATMA, can offer a useful and supportive addition in discourse analysis, in quantitative and especially qualitative data analysis and data coding following GT: the discovery of social structures or describing cultural phenomena in the social world through coding processes, which in turn should reveal theoretical concepts, visualize them, and thus make them understandable. Moreover, in the light of vast amounts of digital materials, digital tools invite researchers to explore their capacity by offering additional tool functions for structural analyses and distant reading (Moretti 2013), like sentiment analysis, visualizations of word distributions, discursive trends as identified by the 'topic finder,' word frequencies, word co-occurrences, and others more – allowing new possibilities for insights in discourse analysis.

With the integration of IT tools and infrastructures into the knowledge production in the humanities, ontological changes take place in the knowledge production; new social, ethical, and political constellations are consolidated, disturbed, or created (Koch 2018, p. 71). Complex human-computer interaction become part of research processes, which may only be understood sufficiently in phenomenological-descriptive and ethical-normative respects (Fritz et al. 2020, p. 3). Moreover, a challenge of digital approaches still is, that "[c]reativity is supposedly reduced to choices of possibilities selected by

programs, causing independent new creations to disappear from the horizon of possibilities in the humanities production of insight" (Koch 2018, p. 69)[2]. The integration of structural approaches into the qualitative hermeneutical approach of SKAD can be understood as an infrastructuring for social and cultural research, and thus has the problematic aspect that "people's discursive and work practices get hustled into standard form" (Koch 2018, p. 70)[3]. It also raises methodological and epistemological issues in studying social reality, which will be addressed and embedded into the development of the D-WISE Tool Suite.

The SKAD works in circular processes or hermeneutic circles of search, selection, analysis, and interpretation of research data, supported by literature work, performed iteratively until the research question is answered (Carter et al. 2020, pp. 255–256)[4]. These basic operations prepare the ground for the intertwining of hermeneutic epistemic processes of SKAD with the structural methods provided by digital tools assembled in the D-WISE Tool Suite.

The HCI-concept in D-WISE seeks to bridge the gap between the manual hermeneutic process and an AI-guided research process enhancing the human hermeneutic process.

3 The HCI Concept in D-WISE

By focusing on building a working environment for integrating digital methods into discourse analysis through an approach in which scholars have an active say in the creation of specific features, can integrate their ways of thinking, and doing discourse analysis, the creation of the D-WISE Tool Suite goes beyond tailoring its features and usability to researchers in the humanities by adapting it to different styles of doing SKADs. The consideration of a variety of styles is a particularly challenging task for HCI design; epistemological specifics, different levels of practice and experience matter. The bandwidth of varying requirements will be tackled in the project's development through continuous feedback loop mechanisms from different angles.

Bringing not only the human but also AI in the loop alternately in the loop, means that human research processes of data acquisition, analysis, and interpretation can be enhanced by AI as well as AI processes can be enhanced by human interaction in combination with machine learning processes. The mutual assistance between human actors as well as AI can act as an ethical control body to avoid the use and development of biased features that lead to stereotypical or discriminatory use and outcome in process of data analysis. Centering Human-in-the-loop and approaching the tool suite development via a) the user stories and b) the fellow program as a link between qualitative and quantitative research, between manual and digital research, can help gaining a more nuanced understanding of relationships and connections, of infrastructures between human and technological components (Koch 2018: 71).

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[2] Koch points this out with reference to Evans 2012.

[3] Koch is referring to Bowker and Star 2004.

[4] Carter et al. on hermeneutic literature review, here with reference to Boell & Cecez-Kecmanovic, 2014.

While the user stories are mainly implemented to support the software development, the following fellow program is created to support the development process as well as the research process after successful implementation of the tool. In a testing phase before and while the fellow program is going on, tutorials and questionnaires will be implemented to not only guide the human through the analysis process, but to similarly reflect the individual user experience and enhance not the user's analysis. By using the tutorials and questionnaires, the human in contrast improves the AI's guiding characteristics, as the machine will learn through these tutorials and about the priorities the researcher sets for the individual research project.

The following sections will guide through the HCI Concept in D-WISE, acknowledging first the human in D-WISE followed by a focus on the strategies putting AI-in-the-loop in the D-WISE project. The latter will give a more practical insight into development process, working mode, and tool features of the Tool Suite, focusing on semi-automated processes of filtering.

3.1   The Human in D-WISE

With the methodological approach of the user stories the D-WISE project cross-disciplinary and collaboratively analyses what the existing tools lack in functions and functionalities and what must be improved to improve the working experience and outcome.

Several Qualitative Text Analysis Tools are available but are often neglected by users. Many tools cannot cope with big data without getting cluttered, because data management systems lack functionality and clarity. Furthermore, users need an extensive technical understanding not only of digital tools in general but especially for the individual tool in use. Workshops, Tutorials and Labs must be studied to get to understand the possibilities of the individual work. Important functionalities are hidden and not transparent in their implementation, what stops many scientists to use them, while it is not possible to describe the process of the digital research and its outcomes and therefore to assure scientific standards.

Even in the process of a critical as well as uncritical user experience or analysis of the usage of a qualitative analysis tool, an improvement and sharpening of the research question and process is happening. The same way a focused or changing research question changes the perspective, reading and outcome of text work and research, in a similar way AI exercises influence on the researcher and the research process. While AI can have a deep impact on manual research, this impact can be experienced both positively as well as negatively[5]. By adapting and improving selected features by building a new web-based tool suite, user stories are implemented in the research process. While there is still the user in the loop, which is the dominant paradigm in AI development, in the D-WISE concept the actors in the loop are switching, so that in a next step thus the AI will be in the loop.

User Stories. Existing Qualitative Data Analysis (QDA) software offer a reference frame for further development of QDA functionalities and tools. They give insight into

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[5] How do computers influence its users by its categorization, stereotypically, gender disparate or even racist presets via biased trainings by humans? See Rodwell in this panel (preprint).

technical possibilities, which functions have proven as useful and demanded and which trends are followed (Schäffer et al. 2021, p. 3)[6].

A key strategy to put the human in the center and to develop the DWTS in a cross-field approach is the applied model of user stories, which furthermore enables the link between manual and digital analysis and as link between quantitative and qualitative analysis. Guided questions are designed to ensure users attention and enhance the reflection process. The template structure for creating user stories follows three key elements: the who, the what, and the why; these fundamental dimensions are then spelled out as "*As a <role>, I want <goal> so that <benefit>*" (Wautelet et al. 2014, pp. 211–212). To articulate informed and productive user stories, comparative, critical analysis and reflection of work experience with existing QDA tools and their missing or insufficient functionalities represents a key element and initial step. Having tested other digital platforms available, both commercially (e.g. MAXQDA, atlas.ti) and open source (e.g. CATMA, WebAnno), different functions and features that could be of interest where listed and categorized. The categories currently in use are general, search, acquisition, coding, reflection, and analysis – all key elements when applying discourse analytical methodology. A few examples of these are:

Category: Acquisition – I would also like to add social media input into my corpus, for example tweets
Category: Reflection – I would like to have an overview of all the work achieved in one session and create a memo reflecting on this
Category: Analysis – I would like to obtain statistics on my search results

This working process, research patterns and coding strategies develop in a tight-knit working modus between the Human Sciences and Computer Technologies teams. The feedback-mechanisms thus acquired have allowed an informed and efficient analysis for adapting human scientists' needs in combination with a technical feasibility analysis that enhances digital support of discourse analytical methodology. Centering Human-in-the-loop and approaching the tool suite development via user stories as a link between qualitative and quantitative research, between manual and digital research, can help gain a more nuanced understanding of relationships and connections – infrastructures between human and technological components (Koch 2018, p. 71).

Making the System Robust for Different Users. While the needs of discourse analytics in Human Sciences differ widely, the approach is extended to another level of putting Human-in-the-loop – via consultation of extended researchers from different disciplines. User stories after tool development[7] will be maintained through the realization of the fellow program, where user stories from different research areas will be developed, analyzed and implemented in the further software development.

While the ways of doing a discourse analytics in Human Sciences differ widely, the approach is extended to another level of putting the Human-in-the-loop – via consultation

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[6] Schäffer refers here to Manovich 2013, p. 29.

[7] See paper by Binder et al. in this panel (preprint).

of extended researchers from different disciplines. Hence, the DWTS will enhance its feedback mechanisms by the implementation of a fellow program — Knowledge-related heterogenous user groups are involved in the software development.

The development of the D-WISE Tool Suite is a mixed method approach from top-down and bottom-up – collaborative efforts of the fellows shall lead to a work environment that works in different contexts, for different research questions and is built incrementally and focus on problem solution (Yimam et al. 2017, p. 6). The dialogue with the researchers from different disciplines will provide a system that enables a on a variety of tasks oriented tool suite and workflow that does not capture the worldview in ontologies based on the author but on the user (Schäffer et al. 2021, p. 3; Yimam et al. 2017). Additionally, a variety of user stories with different research questions may prevent the phenomenon of automated bias, where automated tools influence human decisions in significant, and often detrimental, ways (Green and Chen 2019, p. 2).

Guided questions shall be designed to ensure users attention and enhance the reflection process. The methodological approach can be enhanced by designing it as a digital tutorial, guiding the human user through a digital tutorial the user itself is advancing in process of working. At the end of the tutorial the user condensates the user experiences to the most important functionalities and oriented after the technical possibilities to realize the functions or to end the process of developing the tool because of technical limitations. This helps not only form a perspective of computer technology to understand what the human scientist need in discourse analytical processes, but also to detect missing and insufficient implementation and realization possibilities.

3.2   AI in D-WISE

Discourse analysis gets enriched by digital methods and features in Qualitative Data Analysis tools, such as topic modeling, co-occurrence analysis, sentiment analysis or by visualization of quantified discourses and patterns, which offer insights into trends and conjunctures, distribution of the usage of words over time. Digital methods also prove to be fruitful where they support the methodical guided reduction of large amounts of text as finding heuristics in the sense of filtering processes and serve the identification of potentially relevant data for manual processing. In this mode of human-computer interaction, the goal is also to constantly improve human analyses and the representations in the AI systems in the loop of our system, creating a win-win situation for both human understanding and training of the AI system. AI is in the loop of human analysis and supports human decision making instead of the human supporting the AI with intellectual monotonous tasks and reviews.

With D-WISE and the combined use of Human-in-the-loop and AI-in-the-loop, pointing to AI guided filter mechanisms and computer tools, efficiency or quality of hermeneutic analyses shall be improved. One main aspect to improve this hermeneutic work with AI is the AI guided process of material collection supporting the human in being able to process larger amounts of text by filtering processes.

Filtering. Potential for automated processes and putting AI-in-the-loop to enhance manual research is relevant in several disciplines, as discourse analysis is a method used in different sectors of human and social sciences. Given the amount of data researchers

can increasingly access via digitized archives, the need for technical solutions and digital tools for coping with these, in questions of collection, analysis, and interpretation, increases with this changing research process and access to born and made digital archival records.

For research processes on complex social realities require the methodologically guided reduction of research material to manageable excerpts by means of filters, filtering is therefore relevant (Koch and Franken 2020, p. 121). AI and algorithms in tools for qualitative discourse analyses offer automated functions for visualizations, coding, and the function of filtering (e.g. theoretical sampling, annotating, development of categories, simultaneous data expansion), supporting quantitative and qualitative analyses. Compared to the manual selection of a small case of resources for the close reading and deep analysis of qualitative data out of the big data, that can be used mainly for quantitative analyses, an automated system of filtering can mean a more efficient and possibly qualitatively enhanced process. Filtering as a method of epistemological reduction makes possible to condensate social reality into manageable excerpts by selecting discursive models representing a saturated cross-section of the most opposing/maximum different discursive statements (Koch and Franken 2020, pp. 124–126).

4 Language Technology: The D-WISE Tool Suite

4.1 Features

The D-WISE Tool Suite is developed since 2021 and designed on the basis of digital discourse analytical approach with focus on SKAD, where hermeneutic-circular methods, filtering and scalable reading are prevalent concepts. Further, AI-in-the-loop, multimodal and big data are core to the D-WISE project and, thus, are considered throughout the development of the tool's features.

There have been significant breakthroughs in various Computer Vision and Natural Language Processing tasks and AI models during the last few years. This progress in uni-modal models like BERT (Devlin et al. 2019) or GPT-3 (Brown et al. 2020) also led to a great leap forward in multimodal AI models, as scientists are starting to leverage these new insights to build models that work with two or more modalities simultaneously. State-of-the-art uni-modal and multimodal AI models like UNITER (Chen et al. 2020) or CLIP (Radford et al. 2021) enable the development of novel features enhancing the quality of (DH) research and allow the D-WISE Tool Suite to handle documents consisting of text, image, video, or audio data, or a mixture of all modalities.

4.2 Data Acquisition

To support the process of constantly building up the dossier of the discourse analysis, D-WISE Tool Suite offers an interface to upload local documents to a corpus or import online documents to the corpus by providing an URL. A more advanced technique is semantic crawling, which is an AI-powered, focused crawling process that — provided with thematic word lists, keywords, a topic, or even a document collection — retrieves relevant documents from the web. The process is developed in a way that users are able

to reduce or extend the corpus in every stage of the work, following the hypothesis that corpus collection is never finished and an ongoing process changing parallel to the analysis process.

An interface is developed that allows to start and stop the semantic crawling process, to proofread the found documents, manually filter out bad results and add meta-information. Filtering out results (explicitly) and, later, working with the found documents (implicitly), creates valuable feedback for the semantic crawler in terms of which documents were considered relevant. This mechanism implements the AI-in-the-loop principle, benefitting both the AI to improve over time and the human researcher by reducing the time to find more relevant documents in a reasonable time.

Every uploaded document runs through a pipeline of multiple, AI-powered pre-processing steps, allowing the tool to extract desired (meta-) information and enrich the data. Examples include filling metadata like date, author, and origin, automatically finding keywords, detecting topics, extracting named entities, or filtering out noisy text passages like ads. In case of images, the D-WISE Tool Suite may automatically find and annotate objects, locations, or persons. For audio and video files, Automatic Speech Recognition (ASR) AI models allow it to automatically transcribe the material. This extracted information is useful in later stages of the research process and enables key features of D-WISE Tool Suite, which are described in the next sections.

4.3   Coding

An essential feature of the D-WISE Tool Suite and one of the main principles of GT within SKAD is the ability to annotate or code multimodal documents. With this effective method, researchers can find and analyze patterns and concepts in their data to discover and elaborate social phenomena.

The D-WISE Tool Suite supports the typical three consecutive coding stages of GT — i.e., open coding, axial coding, and selective coding — by offering functionalities like creating new codes on the fly (open coding), updating codes, building code hierarchies, or linking codes in a management view to refine codes and find potential relationships (axial and selective coding). The annotation module is accompanied by a code editor that allows to define hierarchical taxonomies. In addition to annotating spans in textual data, D-WISE Tool Suite supports annotating regions in images, sequences in audio streams as well as passages in videos. Further, the D-WISE Tool Suite supports document-level annotations denoting e.g., predominant categories or common topics. Hierarchical document-level classifications of multimodal data like that can help to organize and retrieve it.

Via functions like highlighting, commenting and annotating, documents of any modality can be edited in a collaborative setting making it possible to work together in teams. Collaboration is achieved through multiple functionalities, the most important one is displaying other users' annotations to compare and discuss contradictions.

The D-WISE Tool Suite plans to include means for fully automated, AI-powered annotation of German or English multimodal data. This feature is of very high importance to the D-WISE project as it allows scaling up and handling large corpora, which, in turn, should improve the quality of DH research. This feature is enabled by state-of-the-art AI models that learn from manually created codes to automatically annotate unseen

data. Following the active learning paradigm, human coders can accept or discard the automatically annotated codes of previously unseen samples and thereby improve the models over time. This leads to a loop of AI predicting codes and humans correcting the predictions until the human researchers are satisfied with the results. This effectively allows researchers scaling up from a few annotated examples to the whole corpus.

In combination with the filtering component, D-WISE Tool Suite also enables semi-automatic annotations by first filtering for specific text passages and then applying certain codes to them.

4.4 Filtering

Another vital procedure in (digital) SKAD that includes the coding methodology is filtering. Here codes are used to find more documents so that the variety of arguments in the social discourse under investigation increases. Therefore, the D-WISE Tool Suite will offer filter functionality to find minimally, or maximally different documents based on used codes.

Besides standard search methods like full-text, keyword, or lexical similarity search, D-WISE Tool Suite will also be able to filter large corpora with AI-powered semantic search methods, like semantic-textual-similarity search or paraphrase mining. In those methods, AI models first compute a semantic representation of sentences or short paragraphs and then use this representation to find the most similar documents in the corpus. With modern clustering and indexing technologies, this can scale up to billion-scale corpora while still preserving real-time capable latencies. In addition, the D-WISE Tool Suite will provide multimodal and cross-modal search and filtering functionality. Therefore, state-of-the-art multimodal AI models are used to represent documents of different modalities in the same search space. This enables modality agnostic searching or filtering with multimodal queries. That is, a query can be either an image, a text, or even a short video or audio clip, and documents of all mentioned modalities will be retrieved.

In the search interface of D-WISE Tool Suite, users can create filters that represent different search methods described above. These filters can be combined with logical AND or logical OR operations. Adding new filters to a query will further reduce the large corpus until a human manageable document collection is retrieved. Furthermore, since it might be helpful to share the search result with other users or refine the filters later, the queries and the retrieved document collection can be saved.

4.5 Data Analysis and Visualization

The D-WISE Tool Suite will be equipped with several analysis functionalities and appropriate visualizations that we consider standard methods of DH researchers including word co-occurrence, concordance, collocation, and frequencies as well as sentiment analysis and topic modeling. These techniques allow for structural analysis as visualization from a distant reading perspective to get a first impression and a first structural qualitative analysis.

Transparency is central to D-WISE. All analysis and visualization functionalities are a product of an understandable, reproducible process so that a cognition process can be guaranteed, and insights can be traced back. Users will have to carefully select what

goes into the visualizations — by manually selecting the data to analyze, formulating a query, and choosing from a range of visualization techniques — in order to maximize the findings and insights gained from them, but also to avoid confusion and incomprehension.

Considering the AI-in-the-loop paradigm, interactive visualizations are a promising direction where humans and AI benefit each other. While humans actively use AI-powered visualizations to leverage their research, AIs can learn from this interaction. Consider data clustering as an example: Data points are visualized on a 2D plane, where distance represents the similarity computed by an AI. Interacting with this visualization by rearranging the data points to create new clusters, adding data points to existing clusters or moving wrongly classified data points to a more fitting cluster creates valuable feedback for the AI, so that it can learn new similarities and dissimilarities. Another example are entity networks where named entities, extracted automatically by an AI, are linked by their interactions, enabling the analysis of cross-document relations. A visualization that supports merging, removing, renaming, and creation of new entities and edges creates a feedback loop where AI can learn about wrong entity identifications, different mentions for the same entity and new relations; also, common errors in the automatic processing — sometimes due to data-collection-specific artifacts — can be quickly fixed for the particular project at hand (Yimam et al. 2016).

The outlined examples are just a small excerpt of a vast, unexplored space of possible interactive visualizations for data analysis. There is considerable development and research potential in the area of interaction and analysis options with multimodal data, especially when aiming to create feedback loops that benefit both humans and AIs. Within the D-WISE project, we aim to further explore this research area. Considering collaboration, the D-WISE project may explore benefits of using interactive, explorative visualizations simultaneously.

4.6 Research Reflections

Writing down and newly gathered insights while researching according to the SKAD paradigm is vital to elaborate patterns and phenomena effectively. Hence, the D-WISE Tool Suite provides functionality to create memos and attach them to all kinds of virtual objects like codes, documents, document collections, saved queries, or visualizations. To keep an overview of memos, D-WISE Tool Suite will be equipped with an interface that allows to list memos created in a particular project, date, or date interval. Additionally, the interface will provide an overview of all actions, e.g., assigning a code to a document, creating a visualization, or creating a document collection. Finally, the interface offers a logbook to effectively describe summaries of a session or discovered phenomena in detail. With the research reflections feature, we claim that scientists can work much more efficiently because manually creating an overview in one application and then switching to another application to write down everything is distracting and takes more time.

4.7 General Features

The D-WISE Tool Suite also provides standard functionalities related to project management, user management, and the overall workflow. It is a project-centered, collaborative web-application, i.e., administrator users create a project and assign or invite other users

to it. Furthermore, project administrators assign different roles to users and thereby allow or forbid certain actions like, e.g., uploading documents, viewing memos of other users, or only viewing a certain document collection. Additionally, the D-WISE Tool Suite is planned to support import and export functionality for projects, (annotated) documents, and codes in common data formats like CSV or JSON. This enables exchanging of data from different D-WISE Tool Suite instances and pre-processing or post-processing data with other tools.

4.8   Related Work

Many different annotation tools exist that offer similar functionality as the proposed D-WISE Tool Suite. Established tools in the DH include CATMA (Gius et al. 2021), MAXQDA and WebAnno (De Castilho et al. 2016).

Common to all tools is the annotation component. As in the D-WISE Tool Suite, these components allow defining hierarchical taxonomies and annotating text spans. However, the workflow and details differ among these tools. WebAnno is a multi-user tool for linguistic annotations and dataset creation and, consequently, offers additional chain annotations as well an annotation process optimized for achieving high inter-annotator agreements. In contrast, D-WISE Tool Suite, CATMA and MAXQDA are designed mainly for qualitative research offering — besides span annotations — additional functionalities like comments and memos to document thoughts. Automating the coding process is an important function of D-WISE Tool Suite to scale-up to big data. The goal is to develop an integration of iterative and active learning into the annotation process similar to WebAnno, but also offer semi-automatic methods like CATMA and MAXQDA.

Being tools for qualitative data analysis, CATMA and MAXQDA offer various analysis and visualization techniques. CATMA comes with its own query language allowing fine-grained analysis, an interactive query builder and multiple pre-defined visualization methods like word clouds or double trees. Similarly, MAXQDA offers search functionalities including keyword search, segment search lemma-lists, Boolean operators and wildcards as well as various visual tools that leverage qualitative analysis. Further, MAXQDA includes means for quantitative analysis and statistical data analysis. In the D-WISE project, we aim to offer selected pre-defined visualization tools which have proven to be useful for discourse analysis, like topic finder, word clouds or double trees. However, our main focus is on developing novel interaction techniques for interactive visual data analysis with AI-in-the-loop.

Handling multimodal data is a key feature of D-WISE Tool Suite. While MAXQDA already allows to annotate texts, images, audios and videos, the D-WISE Tool Suite will also offer functionalities to retrieve, search and analyze such material. Novelties of the Tool Suite also include the automatic retrieval of new sources (data acquisition) as well as the exploration and filtering of the found material (filtering). Equipped with state-of-the art multimodal AI models that enable the development of powerful automation, search and analysis functionalities, interactive visualizations that hone the AI-in-the-loop paradigm, novel data acquisition and exploration features as well as means to collaborate effectively, we believe that the D-WISE Tool Suite will be a noteworthy contribution to the DH community.

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