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SpaceLog: An app for collecting multi-modal place-based data

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Abstract: Collecting multi-modal data in the context of self-reported health relies on a well established inventory of qualitative methods like go-along interviews or photo documentations. Building on and aiming at established workflows of place-based Geoinformation Systems (GIS), in this paper, we present our mobile application SpaceLog and an associated dashboard meant to provide a digital means to collect rich multimodal place-based data (speech, audio, emotions) enabling mixed-method analyses addressing qualitative empirical research on place-based individual wellbeing.

Keywords: Well-being, self-reported health, place-based data-collection, mobile app

1 The need for place-based information on self-reported health

This paper introduces a novel mobile data collection app named SpaceLog specifically developed for capturing individual place-based perception and wellbeing. In the context of Health Geographies, after a thorough review of available data collection tools and methods for capturing individual place-based perception and wellbeing we developed a mobile application to suit this task. In this introduction, we will first motivate the specific need addressed and why to our knowledge no tool fully reflects this demand.

In the last decades, there has been a notable shift from paradigms of pathogenesis ("what in your environment makes you ill") to perspectives of salutogenesis ("what in your environment keeps you healthy") [Ant]. Accordingly, building up a better understanding of situated experiences and place-bound practices of health and wellbeing in specific environments has recently gained momentum ([Ges92]; [GK16]), especially when dealing with spatial prerequisites for mental and social health ([WEG+21]; [Kos17]). Detailed data on individual person-place interactions has become mandatory to provide deeper insights into individual experiences of wellbeing [KYY+23]. This gets even more important when tracing local changes over time, e.g., in urban environments in the context of climate change. Well-established methods of self-reported health [TJ18] involve descriptions and self-assessments of embodied experiences ("how do you feel?") and thus provide an "inside view" of participants in specific places, adding significantly to the spatial footprint of socio-demographic or behavioural data when investigating specific conditions of wellbeing for different social groups. Such data extends on established mixed-method approaches from empirical social studies like ex-post-questionnaires or interviews ([Fli08]; [BB22]) in providing very detailed case-specific data sets. Accounting for the high resolution on a limited number of instances we call such data sets "rich data", in general accordance with Miller and Goodchild [MG15].

Corresponding data sets detailed enough to capture the full variation of cases, but also usable in statistical analysis are not easy to acquire. Geolocated social media data is not sufficient to capture the full notion of individual place-bound experiences of wellbeing, because posts tend towards a positivity bias [WBH+21]. Consequently, data on self-reported health are often collected at great expense specifically for the purpose of single empirical studies. As they explicitly involve individual perceptions and experiences of place ([Cre15]; [Sch02]), this is not quite the same task as collecting data in the context of volunteered geographic information (VGI, see [Goo07]) where multiple mobile apps pre-exist aiming at the distributed, inter-subjective, and verifiable collection of data about the environment itself. Therefore, providing a mobile data collection app on individual place-related wellbeing that is robust and configurable for different study designs and data privacy policies is an open task for research software engineering [FGG+25] in the field of health geography.

In this paper, we provide an overview of pre-existing efforts in designing and digitising methods for mobile data collection on individual emotions and wellbeing (section 2), outline requirements for a suitable app (section 3), technically describe the architecture and implementation of the app SpaceLog (section 4) and report on an early evaluation of the user experience (section 5) before concluding and naming future development goals.

2 Related Work

Building on the foundational work of Tuan [Tua75], Agnew [Agn14] and Cresswell [Cre15], and in strong congruence with conceptual research on place in health geographies [GK16], our research builds on perspectives taken in the context of place-based Geographic Information Systems (GIS) ([PWK19]; [WMC20]; [Gao22]). In addition, following the metaphor of qualitative GIS, Pavlovskaya [Pav17] first suggested how to involve multi-modal data in geoinformation systems, gaining better representations of the everyday experience of place and thus augmenting classical map artefacts. Enriching place-based data on individual wellbeing with multi-modal data (i.e., photos, sound recordings, voice recordings, mobility data, and emotion scales) allows for different types of consecutive multimodal analysis [Dic20].

Once again, other than the rich support of apps for Volunteered Geographic Information (VGI) [Goo07] or Public Participation GIS approaches [BK14], we do not aim at citizen science or citizens collecting inter-subjective, and verifiable data about an environment. Instead, we focus on the collection of data representing the health-related place-based practices and needs of different participants in order to inform further action in the field of public health [Tur12] by suitable follow-up analysis. Accordingly, when following the general approach of self-reported health [TJ18], we deliberately delineate our methods from predominantly quantitative behavioural and cognitive research investigating wellbeing by body sensors measuring stress and arousal [ZRL+16] or (outdoor) eyetracking ([KBG+21] or [KGK+14]). Instead, our data collection app refers to an inventory of methods genuinely developed in empirical social studies. Münderlein [Mün21] provides an exhaustive inventory of qualitative data collection methods that can be combined to capture individual wellbeing in urban environments, e.g.:

1. walking experiences (e.g., go-along interviews, see for comparison [DK22])

2. photo-based methods (e.g., reflective or autophotography, see for comparison [Dir13])
3. experienced emotions (e.g., established scales and indexes, see for comparison [THF+07])

Rich data sets supporting those methods provide the opportunity to relate the self-reported assessment of wellbeing to a self-described environment, which allows for distinguishing different perspectives on the same place. In addition, such rich data sets can be easily searched for similarities, dissimilarities and spatial clusters [Kre18] providing additional quantitative indication assisting qualitative research studies.

Within the broader lifecycle of collecting, processing, analysing and then visualising, modelling or simulating data, research software engineering (RSE, see [FGG+25]) addresses all phases of the software engineering process. These range from requirements engineering and software architecture to development, testing and eventually maintenance. Addressing very specific research practices following specific epistemological paradigms, RSE research is well aware of the challenge of providing flexible, modular, and easily configurable applications to have the chance of deploying "long-living, sustainable assets" [FGG+25]. These efforts also include the awareness that development might be temporarily suspended during active use when looking for funding while trying to build up a strong user community. Our discipline-specific work in developing a novel mobile and modular data collection app finds itself well aligned with all of these concepts. Moreover, our data format integrates into well-established analysis workflows in health geographies enhancing resolution and comparability of data on individual wellbeing. Generally, we recognise the importance of the FAIR principles increasing transparency, reproducibility and reusability of actual research practices and results [BCK+22].

Focussing on collecting data of individual wellbeing and perception, several mobile applications are already available. However, they are mainly used mapping geo-features on site to allow for their later integration in geoinformation systems [HVP23]. Therefore, a focus is put on geoinformation. However, handing mapping tasks to participants in social studies is not different from the well-known method of mental maps [DSG+82] with all its limitations and caveats. This is not guiding for our research, as we want our participants to report on observations of wellbeing by using different types of media. These are related to specific geo-coordinates accessible to statistical analysis, but they are not forced into pre-sketched spatial representations by drawing points or polygons. Some applications already use the option to incorporate images to enrich the mapped features [NDLC20], but again, these applications are primarily designed for environmental science observations (e.g. eBird, [SWI+09]) or on mapping specific items for later research in the context of citizen science [NDLC20], not for collecting data on individual perception.

However, also in the context of self-reported wellbeing, mobile applications have been developed earlier to collect data on individual wellbeing in a high temporal resolution (e.g. Mappiness, see [MM13]). In this specific case, images were only used as vehicle carrying geo-tags and associated emotional assessments of place, and aggregated spatially providing maps of wellbeing for specific places. Recent approaches further explore the use of multimodal data by involving ambient noise, voice recordings, image and video data looking for correlations between emotional assessment and features in those artefacts (e.g. comparing wellbeing to greenness share and distribution in images, see [KNJ+23]; [NKW25]).

We conclude that the existing solutions do not cover the complete process of documenting multimodal on site observations linked with the concept of self-reported wellbeing yet. As most of the applications are bound to specific domains, they focus either on georeferencing different objects or they emphasise the process of reporting or self-assessment. Expanding on these efforts, we derived requirements for a mobile application supporting all of the use cases considered on an integrated, configurable platform.

3 Requirements

Based on the use case introduced above, we can now identify single requirements. In this section, we will not only name them, but also comment on the rationale behind them.

(1) Location-based observations are the core object of the data collection process. Although this seems just a detail of data management, this requirement is actually quite important. Other than in geo-information systems, the core object is not a spatial entity, but place-relatable via its geo-coordinate. An observation object is composed of observation data and a spatiotemporal footprint (GNSS coordinate and timestamp). In congruence with place-based GIS (see [PWK19]; [WMC20];), the main advantage of this approach is that all spatial extensions of experienced places can be inferred by aggregating study data and there is no need to pre-assume geo-features of interest.

(2) The main study task is clearly visible when collecting data. To keep the data comparable, the study task must be clearly visible for the participants when they actually produce data. This means that all operations for recording and assigning data to an observation instance have to be accessible from a single screen containing the main study task. In special, this is due to the learning from earlier studies that there can be either predefined places and an open exploration task (“How do you feel at each place? Take a photo!”) or a very specific task and an open spatial exploration (“Look for downtown green spaces and take a photo!”) but not both at the same time. Keeping the setup completely open will result in unrelatable data.

(3) It must be possible to record place descriptions and think-aloud assessment of wellbeing on site. To cover the spectrum of on-site experiences, the app should especially facilitate to capture think-aloud notes on how the participants perceive their surroundings on site and how this perception influences how the participants feel about it. This must be possible by typing text or by voice recording respectively to account for different user preferences.

(4) It must be possible to record additional multimedia (image, sound video) to illustrate the scene perceived. To illustrate the actual view that the place description and assessment is built on, the app must support capturing images, videos and audio. It should be possible to capture the media directly, but also via access to the image gallery of the device to upload pictures taken outside the app. Each media entry must be accompanied by the option to erase data from the current observation. This is not only required because of local data privacy regulations in study contexts, but also allows the user for cleaning observation data on upload.

(5) Observation data must be shared by explicit consent. Data must never be shared silently by background upload, but should be released by a deliberate click upon review. This should be done on the same screen holding the study task and the observation data collected. On upload, the geolocation of the observation is retrieved and linked to the observation data.

(6) Each observation must be annotated by structured assessment. Upon uploading an observation object holding one or more media items, the participant is asked to provide some structured assessment of the overall observation (e.g., revealing emotions or classifications like "Wellbeing" or "Perceived urban density"). For better comparability between participants, index scale labels (e.g. [THF+07]) and steps (e.g. Likert) must be pre-configurable. Also, the number of scales is predefined when creating a specific study and should be nested pagewise (e.g., when using several established emotional indexes simultaneously). Additionally, the option to enter text as qualitative codes classifying the observations made should be configurable. The functionality should provide the user with the option to enter free text as labels to openly describe and characterise the observation made.

(7) On study startup, basic participant data should be entered. On study startup, participants should be asked to enter basic socio-demographic context data on their background. This allows for analysing group-specific differences in framing/assessing specific places.

(8) The user interface should be presented multi-lingually. To make use of the mobile application in different studies, configurability has to be provided to present multilanguage software texts and study content. Beside the advantage of hosting studies with international participants (e.g. tourists), this is especially useful to check for intercultural effects on wellbeing.

(9) Acting as a platform, the mobile app should be capable of hosting multiple studies at the same time. In addition to functional requirements, it is important to have the app (re-)useable in different (parallel) study contexts and not limited to a single study setup. This involves a selection menu on app startup to register with the specific study profile the participant is willing to contribute to. To anonymize case data, the use of unique identifiers (IDs) instead of user names is mandatory.

(10) Legal requirements To use the application in different regional contexts, the storage of the collected data has to be aligned with regional data protection laws. The app is developed for specific use in studies conducted by research agencies. This requires the compliance to data protection laws for specific host organisations. As benchmark we used the General Data Protection Regulation (GDPR) from the European Union. By definition, the use of a personal identifier as well as location data is classified as "personal data" and therefore the permission to collect this information has to be granted in advance. In addition, the encryption of the information has to be ensured. For data storage we use a local minio server instance based at Friedrich-Alexander-Universität Erlangen-Nürnberg. Of course, the server instance holding the study data must be configurable in future versions to allow for use in different legal environments. Additionally, we use encrypted connections to transfer the data from the participant's devices to the storage. The retrieval of the collected data from the server is restricted by access tokens. Most importantly, users have the option to remove their data from their observations. To ensure the correct rights of access, we use study specific privacy policies to ensure the compliance with the specific host organisation. In most cases, this must be done in person and requires the approval of the participants. We recommend handing out IDs for the use of the application after signing the privacy policy to assure efficient single blind anonymisation.

System architecture Based on these requirements, we developed a system architecture that complies with privacy regulations and allows several study setups to be used within the application in parallel (see Fig. 1). This architecture stores the study configuration and the study data separately. Once the app is opened, the configuration files are fetched and the selected study profile is loaded into the application. On submit of an observation, the data is uploaded to a file based storage server to allow for easy data access for further analysis after the data collection process. The first step in the analysis process is providing a dashboard view of the collected data, which is described in detail below. Especially lightweight, map-based visualisations provide initial insights into the collected data. For further visualisations, the stored study data can be downloaded, and access to the raw data can also be granted by providing specific data storage keys that only give access to the corresponding studies. Our export function does not currently adhere to specific geodata standards, as we are gathering experience of the needs of different target groups of researchers.

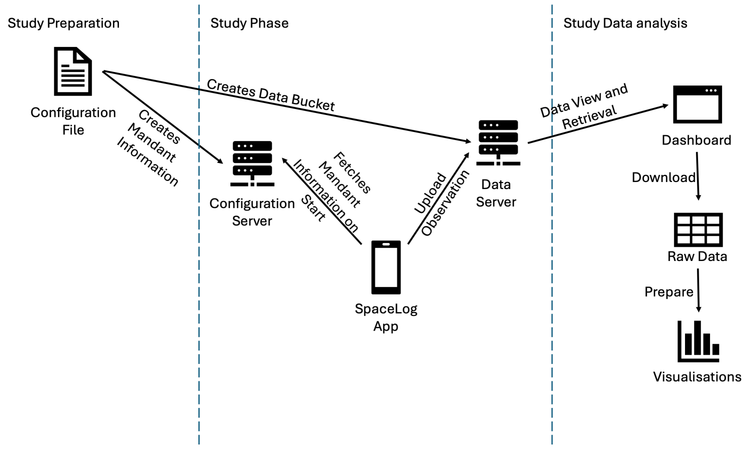
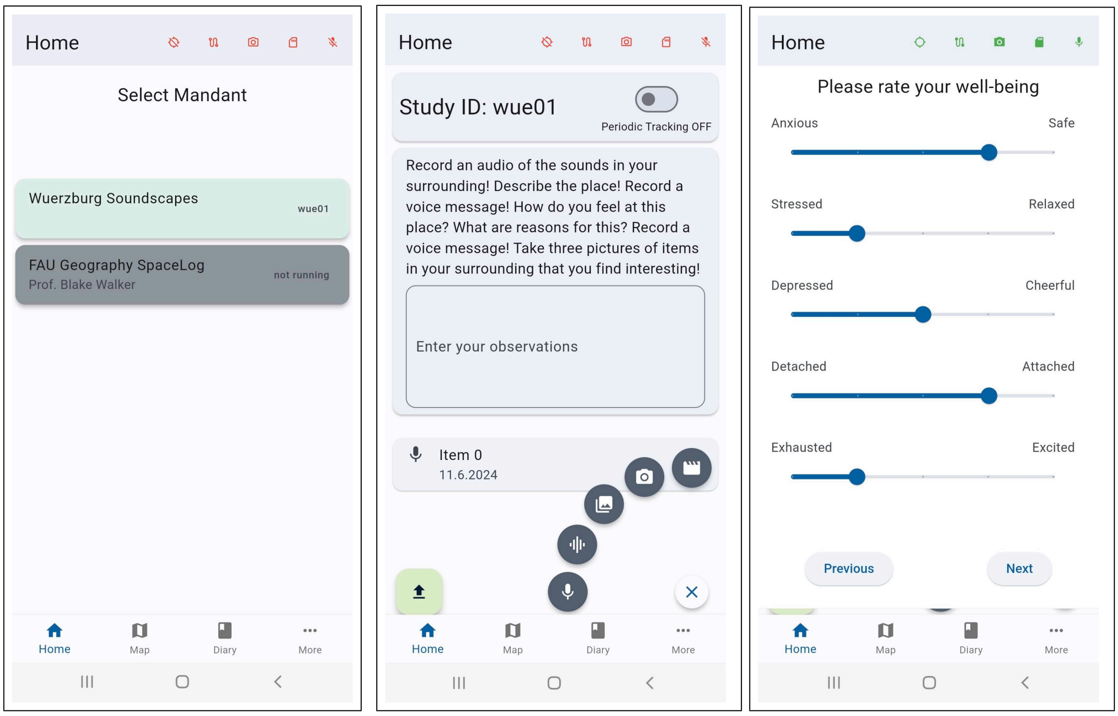


Figure 1: System Architecture

4 Implementation

The main application runs on mobile devices and is implemented using flutter, which allows for a single code base supporting IOS and Android devices. The configuration server runs on python, whilst the data server uses the minio pre-defined API endpoints to store and retrieve data. To facilitate the on-site process of joining a study and entering observations, we created a workflow for users to participate in only one single study at a time, to enter observations for this specific study and to review own contributions on a map and in a diary (Fig. 2). Because users should not be confused by entering information for different studies at the same time, the app starts with a study selection screen (Fig. 2a). After selecting a running study the user is asked to enter an ID, which could be either randomized or assigned when joining the study. This step is followed by an on screen tutorial for using the app, which concludes by asking for the device permissions needed to collect data on site. These include permissions for the devices camera for taking images and videos, the microphone for entering voice recordings or ambient noise, access to storage for uploading images taken outside of the app and the location sensor for retrieving the specific location of an observation. On completion of these steps, the main observation screen is shown (Fig. 2b).



(a) Study selection (b) Entering Observations (c) Index scales (e.g. emotion scales)

Figure 2: Screenshots of our App SpaceLog

This screen is separated into five display blocks. In the navigation bar on top there can be seen, which permissions are granted. Beneath, we hold study metadata. Underneath, there is a text block and a text field to enter an observation. The text block displays the instruction of the active study. To add written text to the observation, a text field is provided. In the bottom right corner there is an expandable button, which opens up five different modes for entering media data. From bottom left to top right they are:

1. enter a voice recording (of unrestricted length)

2. enter a 5 second audio (e.g., for ambient noise)

3. select an image or video from the gallery of the device

4. open the camera and take an image

5. open the camera and take a video

After entering a data object a new item appears beneath the text field. By swiping it to the right, this item can be removed from the current observation. If the user is pleased with the amount of data added to the current observation the green button in the lower left corner is hit. At this point in time, the location for the observation is retrieved and an overlay screen asks for manually entered classification of the observation according to the (emotional) index scales configured (Fig. 2c). The following items are configurable: (1) Likert scales as slider values, where the labels of the scales and the steps of the sliders can be configured when creating a study. (2) An input text field to enter text labels which are not pre-configured, to give the user the option to tag freely what is represented by the observations made. The different classifications can be structured into different subcategories, which can be configured onto different pages of the overlay. After filling out all of the mandatory classification items, the current observation is uploaded to a server run by the study hosts.

Fig. 3 shows the activity diagram of a single observation that was just described by UI interactions. This workflow highlights the configurability of the approach. The most relevant actions besides the data collection process are the submission of an observation and the upload of the observation respectively. The first loop from start of an observation until the submit observation consists of multiple possibilities to add multimodal data to the observation. After the submission, the user is asked for retrieving the current location of the mobile device. If access to the location service is granted, the workflow continues, if not, the observation cannot be uploaded. This choice of break condition is based on the principle of location based observation objects. By reminding the user every time the location is retrieved, the consent is asked for on site. This is especially needed, because even if the

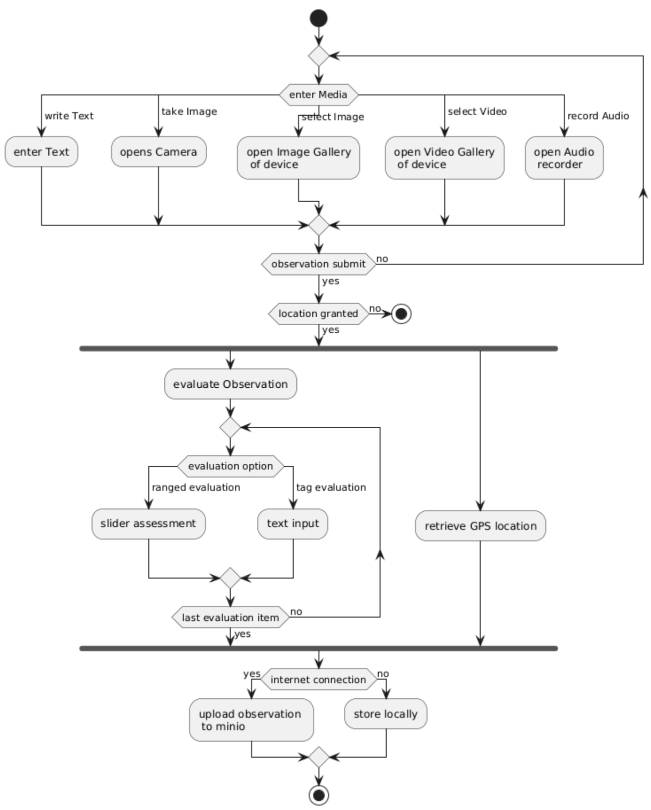


Figure 3: Activity Diagram of a single observation

data is pseudonymised, the location
still remains as traceable footprint. Whilst the observation object is the main centre of interest, it must at least have one media object attached and the location property must be present. The further evaluation of the observation is based on the pre-configured tags and values for the specific study. After all of the evaluation options are filled in and the current GPS location is retrieved, the workflow continues with the upload of the observation to the storage server or a local storage if no internet connection is present. This marks the end of one observation collection process and the next observation collection process starts.

For user convenience, we integrated both a map and a diary tab to provide users with an overview of the temporal and spatial structure of their own submissions to the study. The map shows the locations where observations were added. In the diary view a calendar in the upper part of the screen lets the user choose a date and view observations submitted for this specific date. If the user intends to delete this observation, we currently process the deletion request outside the application, according to data pseudonymisation information. The More screen is a simple settings page, where the user can manually switch to one of the preconfigured languages of the application and can switch the study selection. When the study is complete, it can temporarily be disabled before taking it out of the list of configured study profiles completely. This provides the option to reopen a study easily if a second phase of data collection is needed.

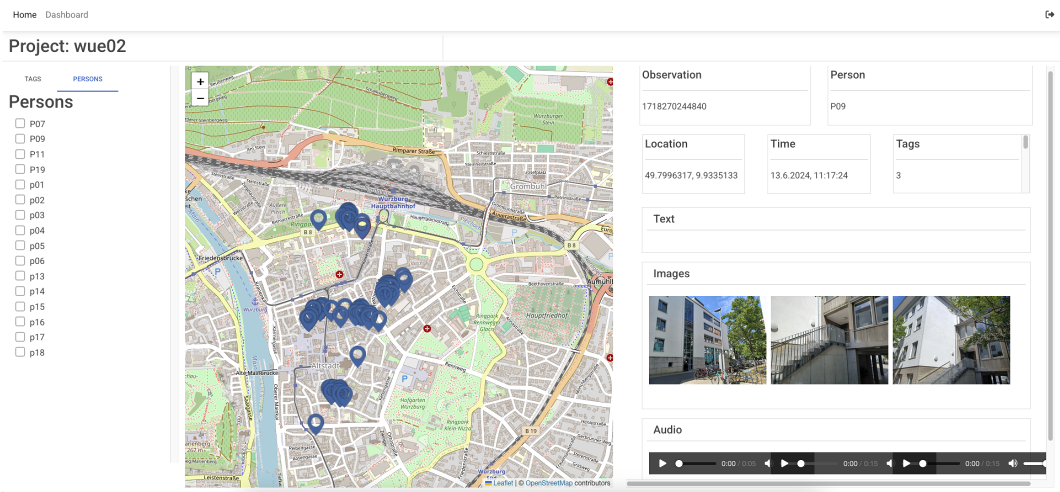


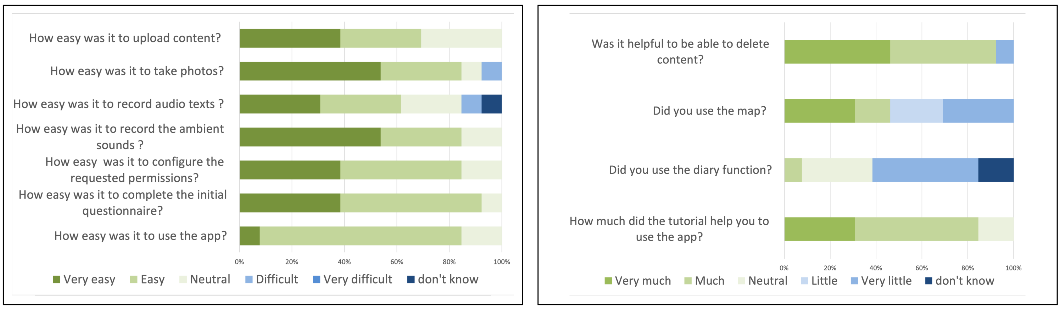
Figure 4: Example dashboard view of SpaceLog study data

The resulting data is stored in a format simply based on files and folders. This folder structure allows for dynamic parsing of the information in different data formats when retrieving the data according to the needed data exchange formats of the specific research discipline using the application. Data can be easily made accessible in a dashboard application which requires access tokens controlled by the specific study hosts (Fig. 4). This dashboard shows a map with location markers for each observation entered within the study. On the left, there is the option to filter by IDs or Tags entered in the open classification. On the right, the observation with its text and media data as well as geographic location, time and the tags from (emotion) scales are shown. This is an easy option for data exploration.

5 Evaluation

To briefly evaluate the use of the application in an on site data collection process, we gathered information from a group of 13 students. The participants are aged between 18 and 35 and therefore can be considered as a target group of young adults. We asked questions on the general usability of the app and on the feedback screens we integrated into the app.

This was done after conducting a first experimental study on perception of their wellbeing and sensed quality of stay in an urban area in Erlangen, Germany. They were asked to walk to three predefined locations within the city and record observations using multi-modal data to capture their view on that place. After recording, the participants rated their wellbeing according to the Warwick-Edinburg mental wellbeing scale [THF+07].



(a) Overall questions regarding the usability

(b) Additional screens and helper functions inside the app

Figure 5: Results of evaluation questionnaires

The students evaluated the app as easy to use. Minor difficulties were reported when recording audio messages and images, which we used to improve the app and our tutorial for future studies. Regarding the additional screens, the included diary was not used at all. This can also relate to the study setup, because the study was conducted at a single day and therefore there was no need to go back and review old observations. The same applies for checking the uploaded locations with the map screen. Even within the small group of students, we were able to gather rich multi-perspective data about certain locations. The included audio snippets often revealed additional information which could not be seen in the images alone.

Overall, we were able to integrate methods of walking experiences as well as photo-based methods and experienced emotions into one single application and workflow. The approach allows for easy collection of data from multiple study participants at once. Therefore, we are able to gather very detailed data sets in a relatively short amount of time. Additionally, the included dashboard provides data access not only for the usage within GIS but also for analysis pipelines focussing on other data streams (e.g., deriving loudness, greenness, etc.). At the moment, we were able to flawlessly collect several hundred observations in four separate study profiles running in parallel.

6 Conclusion

In the context of Health Geographies [GK16], understanding of place-based, situated experiences of health and wellbeing in local environments gains attention. Collecting multi-modal data in the context of self-reported health relies on a well defined inventory of methods [Mün21]. Building on and aiming at established workflows of place-based GIS [Kre18], we present our mobile application SpaceLog and an associated dashboard meant to provide a digital means to collect rich multimodal place-based data for mixed-method analyses involving qualitative empirical research.

Especially for the purpose of self-reported health our workflow supports (1) the integrated collection of multimodal and sentiment data representing individual perspectives and assessment of specific places. (2) Data are stored on a secure cloud service according to requirements of data privacy. (3) Configuring different study profiles allows for (re-)usability of the application in several studies at the same time. With login to the specific study profile, researchers involved with the study can use (4) the dashboard to investigate the data gathered so far and generate first hypotheses on differences in the data.

7 Future Work

Currently, we explore the added use of the application in a large consortium composed of researchers from urban planning, environmental psychology, geo-linguists, cultural geography and computer science collecting user data in urban environments[1]. Given the integrated workflow and the configurability of study profiles, we anticipate that SpaceLog can be used also in different study setups, e.g. in implementing the collection of autoethnographic multi-modal data in research diaries [Cha11] in preparation of hermeneutic coding and analysis of the observations made. Even if the analysis process is done completely qualitatively, SpaceLog can help in scaling the process by offering a single workflow to stick to on every observation and an integrated dashboard for exploratory visual inspection. In general, we are aiming at providing a transferable solution that can be rolled out in different disciplines, and thus providing us with a strong user base.

After a successful flawless test phase, next steps will focus on more repetitive scaled study setups with research partners and evaluate different mixed-methods approaches comparing SpaceLog data to sensor data of the environment. In long-term observations, we will also be able to identify time-geographic effects [Mil18] like time of the day, season, or weather conditions on altering the character of a place for individual wellbeing.

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[1] (https://www.phil.uni-wuerzburg.de/gls/)

Erlangen-Nürnberg for this purpose to fund a student assistant and mobile hardware.

Software Availability: SpaceLog is published in both Apple App store and Google Play Store. The corresponding dashboard is hosted at the Institute of Geography of Friedrich-Alexander-Universtität Erlangen-Nürnberg. All work presented is based on a release candidate for SpaceLog on Android, which can be made available on request alongside the related dashboard.

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