Integrating Industrial Design and Geoscience: A Survey on Data-Driven Research to Promote Public Health and Vitality

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ABSTRACT

With the rapid advance of information communication technologies, unprecedented volumes of environmental and behavioral data have been generated and provided researchers with new pathways to develop strategies and interventions. In digital public health, there has been an emerging interest in promoting vitality based on multidisciplinary research. However, few works have been conducted on facilitating data-related collaboration in vitality research. This paper presents a survey study for the development of a data-driven service system to support multidisciplinary collaboration in vitality-related projects. Our survey received responses from 38 researchers, primarily from Industrial Design and Geoscience. From this survey, we learned both common ground and different research experiences between the two disciplines, regarding the collection, management, and analysis of data. Based on our findings, we proposed a system architecture of a data platform, and specified a set of functions that can assist researchers working from different disciplines in sharing, collection, processing, and analyzing vitality-related research data.

CCS CONCEPTS

• **Information systems → Data management systems**; • **General and reference → Surveys and overviews**.

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KEYWORDS

Digital health; data platform; multidisciplinary collaboration; vitality; survey

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1 INTRODUCTION

The prevalence of sedentary behaviors and physical inactivity increases the risks of developing chronic conditions, threatening people's physical, psychological, and social well-being [23]. One way to reduce the adverse impacts of sedentary lifestyles for increased health and vitality is to encourage individuals to develop physically active behaviors, such as running, walking, cycling, as everyday activities and recreational sports[1]. In digital public health, technologies have brought forth a data-driven perspective to vitality promotion. In this case, data related to PA behaviors and socioenvironmental factors could be leveraged to inform health policies and empower interventions. Vitality has become a worthy topic of study in many data-heavy fields, such as Industrial Design (ID) and Geoscience.

Increasingly, ID researchers investigate vitality interventions based on various data-enabled systems, such as activity tracking devices and digital games. The rapid advance of ubiquitous sensing, artificial intelligence, and Human-Computer Interaction (HCI) enriches the variability of data collection and increases the smartness and interactivity of such interventions. For instance, through integrating the sensing and data-generating technologies into mobile and wearable systems, Do Change platform [6] collected physiological, emotional, and movement data to build personal databases. Additionally, Kulev et al. [12] applied deep-learning algorithms to the long-term databases from multiple sources to distill behavioral patterns and develop vitality profiles for personalized health-promoting strategies. Based on the collected and processed information, early ID studies focused on meaningful data visualization (e.g., [22]) and persuasive interactions (e.g., [20]) to increase self-awareness and stimulate spontaneous actions for improved vitality.

Over the past years, Geo-scientists have become interested in studying the vitality of natural and built environments by examining relationships between environments and human activities (e.g., walking, cycling, and running). By using GPS data collected from cyclists, Ton et al. [24] built a route choice model for cycling in the city of Amsterdam based on a range of individual, network, and contextual attributes. Sileryte [21] developed an approach to assess the conduciveness of urban networks to running activities based on public trajectory data generated by sports tracking application. Gao et al. [10] studied cycling duration nationwide, taking individual and household characteristics, as well as environmental variables into account. Based on an extensive review of articles related to PA, Barnett et al. [7] extracted several built environmental attributes, which can be associated with older adults' total PA and walking. Similarly, Marquet and Miralles-Guasch [13] found significant influences of the vital built environments to older persons' walking behaviors. Mertens et al. [16] distinguished objective and perceived attributes of environments, and conduct a cross-sectional study of cycling to identify objective environmental factors for biking.

The above-mentioned studies from ID and Geoscience utilize data to address the research context of vitality very differently. Yet, either the bottom-up or the top-down strategies have their limitations. With a strong engineering focus, ID research projects have generated applications for vitality promotion in various social contexts[18, 19]. However, technological developments have been criticized for the ignorance of larger contextual information, such as policy and built environments[11]. Also, few attempts have been made to use insights from geography research for designing health technologies. We think the approaches from ID and Geoscience might be merged, and their strength could be leveraged to compensate with each other. For instance, data analysis from Geoscience would provide insights into the influence of social-environmental factors on vitality. Accordingly, designers would develop solutions to intervene in individuals' behaviors. In return, the newly developed technologies can be leveraged to generate data as new research materials for design researchers and Geo-scientists. To investigate this research concept, in this paper we present a survey study for developing a data-driven service system to facilitate collaboration on vitality research between ID and Geoscience. Next, we elaborate on our study design and results in some detail.

2 SURVEY AND KEY FINDINGS

There have been many data platforms developed to share data-generated insights on health and vitality, such as Public Health England [3], The Copenhagen Center for Health Technology [2], Health Data NY [5], Sports Data Valley [4]. Several studies have shown that such platforms can provide various opportunities to facilitate research and support collaboration among agencies, practitioners, and researchers [14, 15]. Our project aims at developing a vitality data platform to not only support the storage and sharing of data but also provide various services for facilitating multidisciplinary research and collaborative work. Specifically, we focus on stimulating and supporting the collaboration between Industrial Design and Geoscience. As the first step to the study, we conducted an online survey to understand the current research practices in the context of vitality promotion and acquire user requirements for the development of a data platform. It was envisaged that the results obtained from this survey would support us to identify a framework for developing our data-driven approach and prototyping the vitality data platform.

2.1 Survey design

This survey was designed with 34 questions to collect data in four aspects: (1) information of the researchers (e.g., age, gender, expertise, etc.); (2) information of the collection and the access of the vitality-related datasets; (3) information of the techniques used for processing and analyzing data; (4) researchers' expectations and future usage of functions in the vitality data platform. The full version of the questionnaire can be found via http://tiny.cc/l8sh7y. In this survey, we focused on obtaining information from researchers working on vitality-related projects based on either Geoscience or ID. The survey was implemented as an online questionnaire using Google forms. We recruited participants by spreading information via emails, taking a snowball sampling approach.

2.2 Findings

Finally, a total of 38 participants (20 males, 18 females) responded to the survey. The responses were from PhD candidates (n=24), postdoc researchers (n=4), lecturers (n=1), assistant professors (n=7), and associate professor (n=2). Among all the respondents, 25 were ID researchers, and 13 were from Geoscience. ID researchers involved in this survey indicated their study fields as 'design' (16), 'health and vitality' (14), 'human-computer interaction' (14), and 'social computing and social media' (6). By contrast, the Geoscience researchers indicated topics in, e.g., 'health and vitality' (10), 'environment' (4), 'urban planning' (4), 'infrastructure and transportation' (3). We applied descriptive statistics to analyze all the survey results. For data collected on each aspect, we firstly provided an overview of the general features. We then described the different results between ID and Geoscience.

2.2.1 Data collection. The majority of respondents (36/38) stated the involvement of collecting vitality data in their research And most of them (in total 29, 21 from ID, eight from Geoscience) indicated using more than one technique to collect data. As shown in Table 1, 'survey/questionnaire' and 'interview or observation' were rated as the two most commonly used tools in the data collection. Digital technologies, such as 'mobile app' and 'camera or microphones', also became popular data acquisition techniques for researchers from both ID and Geoscience. Notably, out of 25 ID researchers, 14 were interested in collecting physical, physiological, and psychological data from human beings, using sensors or activity trackers. By contrast, only one Geoscience

Table 1: An overview of the reported data collection methods from the survey

	Industrial Design	Geo-Science
Collect vitality data by self	**21/25**	**12/13**
Forms. survey, questionnaire	21/25	9/13
Transcript of interview or observation	20/25	5/13
Mobile app	10/25	4/13
Camera or microphone	9/25	2/13
Sensor & activity tracker	14/25	1/13
Crawling from website	4/25	1/13
Design process output	1/25	

Table 2: An overview of the third-party data usage from the survey

	Industrial Design	Geo-Science
Using data from the third party	**15/25**	**11/13**
Multiple data sources	**7/25**	**7/13**
Statistical office	4/25	8/13
Research collaborator (commercial/academic partners)	8/25	2/13
Open data	10/25	5/13

researcher mentioned the usage of sensors in data collection. From this survey, we learned that the first-hand data is essential to vitality research, and design researchers pay extra attention to using sensors to collect data about individuals' health status objectively.

Besides collecting data by themselves, many respondents (26) relied on data from the third-party. As shown in Table 2, researchers from Geoscience and ID used third-party data at different levels. In general, most Geo-scientists (11/13) used third-party data in their studies, and over half of them had access to data from multiple resources. In ID, 15 out of 25 researchers used data from the third-party in research, and only seven of them used data from multiple resources. Regarding the resources for gathering data, for Geoscience researchers, eight retrieved the data from 'regional/national statistical offices', five used 'open data archives', and two received data from 'academic or commercial partners'. In contrast, ID researchers used 'open data archives' and 'academic or commercial partners' data more often, and had less access to data from 'regional/national statistical offices'. To summarize, we saw significant differences between the two research fields in using third-party data: Geo-scientists applied the third-party data in vitality research more necessarily than design researchers. Yet, ID researchers relied more on academic and commercial partners to access third-party data than Geoscience researchers.

2.2.2 Data management and analysis. Out of the 38 respondents, only 11 (eight from ID, three from Geoscience) further described how they work on data management and analysis. Regarding data management, five had their vitality datasets stored locally, three used the services from their research institutions, two used commercial services (e.g., GitHub, drop-box, google drive, etc.), and one collaborated with public organizations. Moreover, their data were commonly saved in tabular form, in the format of, e.g., csv, excel, spss sav, etc. Among those 11 respondents, six had their data shared with '1-3 collaborators' and two had 'more than six collaborators', while the other two indicated that the datasets were not sharable. Regarding the data analysis, out of the 11 respondents, 10 stated 'data visualization', eight stated 'correlation', six stated 'regression', and four stated 'comparison'. We also found that studies in these two disciplines might require different analytical methods. For instance, among the eight ID respondents, five indicated the use of 'thematic analysis', which is commonly used for qualitative research [9]. In contrast, Geoscience has some specific methods for spatial operations, such as spatial overlay, buffer operation, and network operation, etc.

2.2.3 Design opportunities for the vitality data platform. We received 32 valid responses that give insights into the development of the vitality data platform. Their suggestions can be categorized into four aspects, including save data, share data, access to data from the third-party, and analyze data.

Save data. Many respondents expressed their willingness to keep datasets online when it can easily comply with ethical and data privacy regulations (e.g., GDPR and FAIR). As one stated: *"I expect that the platform can help with the short and brief ethical process, at the same time, it still can protect data of research subjects safely"*. As ID researchers tend to collect data using prototypes, they expected a platform could be used as the backend connecting to their prototypes in real-time.

Share data. In our survey most respondents (27/38) were willing to share their research data. They believed such data sharing would produce mutual benefits to researchers working on similar projects and help them establish collaboration. However, the privacy and ethical approval were still the prerequisites to sharing data. As one respondent stated: *"I would if I had asked proper consent and I was convinced of the stability and security of this new platform"*. Some respondents also tried to figure out a solution for safer and easier data sharing. For example, they recommended publishing the metadata to describe their datasets and research topics. Then, people who are interested in accessing the data can contact them to get permission. Moreover, rather than sharing the raw data, they wanted to share aggregated data at different levels.

Access data from the third-party. Another desire was to access data from other resources. Two design opportunities can be derived from researchers' feedback. First, they expected different third-party data sources could be indexed and updated based on specific characteristics. As one commented: *"give us a clear category of datasets with the data type, accessibility, data size, etc."* Second, they hoped the platform could help them with finding data sources related to specific parameters of their research topics/projects.

Analyze data. Our respondents also described some opportunities in supporting data analysis. One could be providing

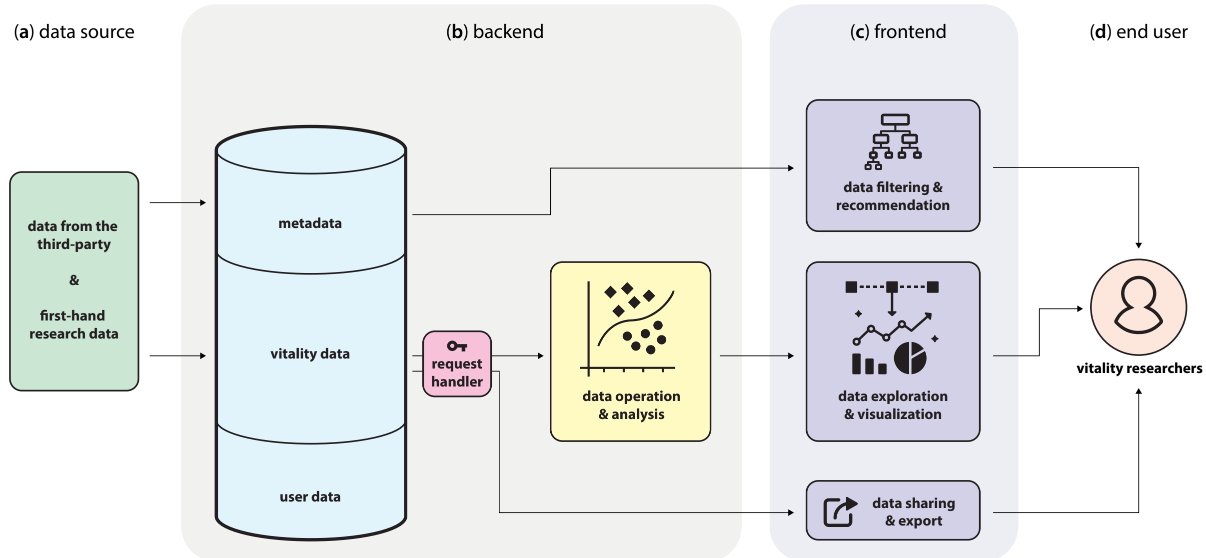

Figure 1: Proposed system architecture of the Vitality Data Center platform.

some simple visualizations to help the initial sense-making process of data. One respondent further suggested to include the online discussion with the data visualization to enhance the discussion among researchers in analyzing data. Moreover, some researchers wanted to improve their skills and knowledge in data analysis in a collaborative setting. One wrote: *"I hope the platform can give me suggestions on which analysis model I need to use based on my data and research questions."* Some also thought about the social aspects: *"we can share methods and experiences about data analysis to support each other's research."*

3 PROPOSED VITALITY DATA SERVICES

Based on our findings, we further design the architecture of our data platform (Figure 1). The purpose of building this data platform is to support data-driven research activities in vitality projects and facilitate collaboration among different research backgrounds (in this case, ID and Geoscience). To this end, we propose a set of modules in the platform that support vitality researchers to collect research data, find useful and usable vitality datasets, access and share vitality data, as well as explore and analyze data.

Save Data. According to the results of our survey, two types of data are considered to store the vitality data platform: 1). data collected by vitality researchers themselves; 2). data from the third-parties (see Figure 1(a)). Regarding the first-hand data, it includes various approaches of data collection in ID and Geoscience, such as questionnaire and interview responses, video, image, and audio records, as well as textual transcripts, etc. Also, the backend of the system is capable of incorporating dynamic data streams from research sensors and digital applications. Regarding the third-party data, those accessible and relevant vitality datasets would be stored and maintained regularly, based on specific criteria. For future work, we plan to figure out the inclusion criteria of third-party datasets.

Find Data. For any cases of the vitality-related datasets, their metadata are collected by the vitality data platform. As such, researchers can not only find datasets that are available on the platform but also know the resource of vitality-related datasets that with restricted access (i.e., with a paywall or access permission). Based on the findings from the survey, the frontend of the system is designed to allow users to browse the metadata, download the available datasets, and redirect to the targeted datasets (Figure 1(c)-(d)). Therefore, the function of data filtering [8] is proposed to implement in the user interface of the data platform. Moreover, we also consider implementing the semantic integration and enrichment [17] to metadata so that the platform can recommend datasets that satisfy individual research interests.

Access and Share Data. Figure 1(b) shows that the database of the vitality data platform saves the research data, which is administrated by a request handler. The request handler decides if a specific dataset is visible to the querying user. In this case, each user is supposed to have an account, which links to data ownership and accessibility. We also design the platform to be able to save the data of all the users safely by the database. As suggested by the survey, in the platform vitality researchers can also share their datasets with others according to the following procedure. At first, a researcher finds an interesting dataset based on the metadata and sends a 'data request' with motivation to the owner of this dataset. Then the owner is notified of the request and makes the decision to either approve or decline the request.

Explore and Analyze Data. Lastly, we design this data platform to support researchers from ID and Geoscience to conduct the online data analysis and exploration with their vitality datasets. This is supported by both backend and frontend of the system. At the backend, as shown in Figure 1(b), data operation and analysis provide basic functionalities (e.g., buffering, regression analysis, thematic analysis, etc.), which facilitates the search, and analysis of the data. At the frontend, as shown in Figure 1(c), a data exploration module is designed to help users to formulate complex queries to find the needed datasets. It also provides a classification of query results, based on criteria, such as data source, geographical region, data format, related activity, and availability. Moreover, various data visualization methods (e.g., maps, charts, and graphs, word cloud, etc.) are applied in the frontend of the system to give a clear picture of the content of datasets to vitality researchers.

4 CONCLUSIONS AND FUTURE WORK

This paper has presented a survey study on understanding data-related practices of vitality research in ID and Geoscience. This survey was designed to collect three aspects of information, including the collection of vitality-related data, the techniques to process and analyze data, and the expected data-related support for future vitality research. Based on the responses from 38 researchers, we learned that there are several common practices and different approaches used in vitality research between ID and Geoscience. These findings helped us identify various user requirements of the data-driven vitality research, in terms of data collection, management, and analysis. Based on the uptake of this survey, we proposed the system design of a vitality data platform to facilitate the collaboration between ID and Geoscience researchers in collecting, sharing, and analyzing vitality data. In the proposed system, we have designed a set of functions, including data store, data search, data share and access, as well as data analytics.

The insights based on our study may need to be carefully interpreted due to a few limitations. First, the survey collected feedback from respondents working in two academic fields, which might not be adequate to sample the data-related experiences of vitality researchers from all disciplines. In the future, we hope to apply the approach used in this paper to study subjects from the other fields of vitality research, such as human movement science, psychology, etc. Second, we conducted an online survey with a fixed number of questions, aiming to collect feedback from researchers as many as possible. This might not be sufficient to reveal all the requirements of our target users. For our future work, we also plan to conduct several field studies, including in-depth interviews, group sessions, co-design workshops, with vitality researchers, in order to draw additional lessons for improving the system design of our vitality data platform. Afterward, we plan to implement the data platform and develop tools and software for accessing, processing, analyzing vitality data. Finally, we will introduce the vitality data platform to ID and Geoscience researchers and cooperate with them to conduct several case studies. Based on results from these case studies, we will validate our approach and further improve our system.

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