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WEB-BASED APPLICATION FOR THE VISUALISATION AND ANALYSIS OF THE ALPHA CITIZEN SCIENCE STUDY IN LAGOS, NIGERIA AND YAOUNDÉ, CAMEROON

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TABLE OF CONTENTS

1. INTRODUCTION

1.1. OVERVIEW OF THE PROJECT

The intended system aims to provide a web-based platform dedicated to the communication and visualization of citizen science data collected in the context of the ALPhA study, conducted by Urban Better | Oni et al., an African-focused global organization dedicated to identifying creative and long-term strategies to address complex urban health challenges in rapidly growing cities. (ALPhA - UrbanBetter, 2021)
The ALPhA study (Informal **A**ppropriation of Public Space for **L**eisure **Ph**ysical **A**ctivity) is a citizen science survey funded by The British Academy's "Urban Infrastructures of Well-being" program, which supports interdisciplinary research that explores how formal and informal infrastructures interact to affect the well-being of people in cities across the Global South (The British Academy, 2021). The project was initiated in late 2019/early 2020 and is set to go on for 2 years.

1.1.A. THE PROBLEM

Exercising or performing physical activity improves the overall well-being of individuals while offering proven health benefits (WHO, 2020). However, in an urban context it may also increase risks of harm from injury, violence, and/or exposure to traffic, pollution, among others, depending on the context. In many high-income countries and more affluent parts of low and middle-income countries, the benefits of physical activity tend to outweigh these risks with access to safe spaces for leisure physical activity (Elshahat et al. 2020).

Africa experiences rapid urbanization alongside poorly governed infrastructure development, a rise in unhealthy living, and physical inactivity. Factors that contribute to increased rates of non-communicable diseases (NCDs), like obesity, diabetes, and heart disease among the population. These NCDs also promote premature death excessively affecting the economically active and thereby jeopardizing development. The urban infrastructure does not provide equally accessible sites for the practice of safe leisure physical activity (LPA), such as parks or footpaths. In consequence, especially in megacities like Lagos, residents routinely appropriate other public spaces to be physically active, including roads, bridges, and unoccupied land, sometimes under hazardous conditions, such as toxic air pollution and increased injury risk. (ALPhA - UrbanBetter, 2021).

During the COVID-19 pandemic and the associated lockdown measures, which included movement restrictions, specifically in Lagos, where you live to a large extent determines the risk and amount of physical exercise that you can lawfully engage in. While affluent-gated communities can access spaces like communal playgrounds along paved streets, middle and low-income communities that make up most residents are forced to turn to motorways and roads, in contravention of lockdown measures with punitive repercussions, highlighting already existing inequalities (Lawanson et al., 2020).

1.1.B. THE ALPHA STUDY

The ALPhA survey uses a participatory approach to investigate physical exercise in public space to re-imagine urban infrastructure for healthy, safe physical activities. The citizen science survey encourages physically active residents who are claiming public space for exercise (ALPhA spaces) in Lagos, Nigeria and Yaoundé, Cameroon, countries with similar populations and NCD risk profile, to share their experience.

The study aims to understand the types of spaces that exist, the experiences of people that use them, and the air pollution, safety, and injury risk exposures these people may be subject to because of the lack of safe spaces. In particular, the study adopted Epicollect5 to collect the participant's geographic coordinates, while exercising at the ALPhA space, and gather information about; the nature of the exercise, its organizational type (spontaneous/organized, individual/in groups), observed health or safety risks of the space together with additional image or sound files.

The study aims for the re-design of urban infrastructure to transform spaces from being presently informally used for LPA to being formally dedicated to LPA in the future. The organizers of the study identify and tackle two key aspects that need to be addressed to induce rethinking of the built environment:

1. Local evidence of the situation
   The situation being: safe public spaces for LPA are not part of the urban infrastructure in African cities, like Lagos or Yaoundé, leading to residents repurposing other (often dangerous) public spaces for LPA risking their health and safety.
2. A community-led network that generates local contextually relevant evidence on how African urban residents engage in LPA. This network inherently serves as advocacy for locally appropriate improvements to urban environments to facilitate LPA (Lawanson et al., 2020).

1.2. PURPOSE OF THE SYSTEM

The results of the ALPhA study shall inform multisectoral actors on urban infrastructure development strategies and the co-design of public space interventions that ensure equal access to healthy safe physical activity opportunities in African cities (ALPhA - UrbanBetter, 2021). To better serve that purpose and highlight the local evidence of the situation, the results of the ALPhA study require a more complex and customizable visualization, than what is presented through Epicollect5 up to yet. Furthermore, essential to driving local (political) infrastructural change is the continuity and growth of the community-led network, that generates the relevant local evidence of the unmet needs of the citizens. For this reason, an interactive web-based system, designed for the exploration of marked ALPhA sites and the assistance of the community of physically active residents of Lagos and Yaoundé is proposed. The purpose and objectives of the proposed system, therefore, are:

- Visualize the results geographically to better inform local urban infrastructure planners, municipalities, politicians, etc. (i.e., multisectoral actors) to support the recognition of the various uses of public space by the citizens.

- Strengthen and grow the ALPhA community network (which inherently contributes to political momentum) through a system that allows the citizens to:
  - Explore the database of ALPhA spaces based on personal needs and avoid areas reportedly experiencing air pollution or high injury or safety risks
  - Interact with marked ALPhA locations and their users through commentary and ratings
  - Receive an incentive to actively contribute to the dataset through Epicollect as well as further information on Urban Better | Oni et al. and other channels to follow to stay updated on the progress of the ALPhA study

1.3. SCOPE OF THE SYSTEM

The project comprises the design, development, and implementation of a web-based desktop application hosting an interactive mapping tool that allows the user to access, visualize, browse, and retrieve customized views (by filtering) of the available data on ALPhA spaces on the Epicollect5 database. Additionally, the system should provide an incentive to interact with the data and mobilize more residents of Lagos and Yaoundé to grow the community of physically active citizens. Thus, it shall offer the user the possibility to rate and comment on the mapped ALPhA spaces and provide further information on the pursuit and progress of the ALPhA study and how to contribute to the Epicollect5 database.

1.4. OBJECTIVES OF THE PROJECT

The visualized data of the web application on one hand serves as an opportunity for policymakers and urban planners to recognize the multiple uses of public space (to address the need for local evidence of the situation) and on the other hand assist the citizen network generating the data, by providing them with a platform to comment on, rate and discover previously unknown safe ALPhA spaces suitable to their personal needs through customizable views of the data. The web system can thereby play well into the overall objective of the ALPhA study which is to address the unmet demand of an LPA supporting infrastructure in Lagos and Yaoundé and ensure equal access to opportunities for safe physical activity for all residents.

1.5. FURTHER REFERENCES

An official description of the ALPhA study and how it is organized can be found on the official website of Urban Better | Oni et al. and updates on the ongoing study can be received via Twitter.

A more detailed analysis of the context, legitimization, and objectives of the ALPhA study can be found in a commentary paper of the University of Yaoundé, the University of Lagos, and the University of Cambridge, published in June 2020.

The paper highlights the issues in urban development in Lagos, which is lacking spaces dedicated to leisure physical activity. These issues have been amplified during the COVID-19 pandemic. It notes the dynamic and inequitable ways that urban spaces are used during the pandemic and the urgent need for local evidence and solutions. The reflections in this commentary illustrate the possibility of rethinking urban development and the reforms necessary to address health inequalities post-pandemic.

In response to the COVID-19 outbreak, Urban Better | Oni et al. also extended the ALPhA project to conduct *opinion analyses of public space leisure physical activity in Lagos* by using social media to explore public perceptions of government lockdown restrictions and the impact of those on the perception, nature, and frequency of exercise in public spaces.

1.6. DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

NAME	DEFINITION
Epicollect5	Epicollect5 is a mobile and web application for free and easy data collection. It provides both web and mobile applications for the generation of forms and freely hosted project websites for data collection. © 2021 Centre for Genomic Pathogen Surveillance, more info available on Epicollect5.
ALPhA space	As defined by the study: Public spaces that are not intended or designed, but that have been informally appropriated for leisure physical activity, by the citizens. (Urban Better, 2021)
WSGI	Web Server Gateway Interface. A calling convention for web servers to forward requests to web applications or frameworks written in the Python programming language.
DBMS	Database Management Service. Software that interacts with end-users, applications, and the database itself to capture, create, maintain, and control access to the database and analyse stored data. MySQL, PostgreSQL, Microsoft SQL Server, Oracle Database, and Microsoft Access are examples of widely available DBMSs. For the development of this project, PostgreSQL has been chosen.
HTTP	HyperText Transfer Protocol. A protocol for distributed, collaborative, hypermedia information systems as the foundation of data communication for the World Wide Web, where hypertext documents include hyperlinks to other resources that the user can easily access.
Web application	Also referred simply as a web app, is a client–server computer program that the client (including the user interface and client-side logic) runs in a web browser.

API	Application Programming Interface. A computing interface to a software component or a system, that defines how other components or other systems can use it or interact with each other, regardless of the programming language implemented, allowing for interoperability. An API defines the kind of requests that can be made to the software and how to make them to obtain a certain response.
REST API	REST: Representational State Transfer. A software architectural style that defines the set of constraints to be used for creating Web Services, to provide interoperability between computer systems on the Internet. A REST API is a web service API that uses URIs, HTTP protocol, and JSON for data format.
SQL	Structured Query Language. A domain-specific language used in programming and designed for managing data held in a relational database management system (RDBMS), or for stream processing in a relational data stream management system (RDSMS).
CRUD operations	Operations to be performed in an SQL database. These transactions describe the overall interaction with the database and contain: Create, Read, Update and Delete.
Dashboard	A type of graphical user interface that provides at-a-glance view of key attributes of the associated ALPhA space.
Active user	In the context of this project, active users are identified as residents who actively contribute to the dataset via Epicollect5 and who may use the proposed web application to aid their decision making.
Passive user	Passive users are identified as users that did not yet contribute to the Epicollect5 dataset but may use the proposed web application to inform themselves. Passive users may include policymakers, urban planners, researchers, NGOs, etc.

2. SYSTEM OVERVIEW

2.1 FUNCTIONAL OVERVIEW OF THE SYSTEM

The system shall be build following a distributed application structure, operating on a client-server architecture, comprising:

I. a web browser as a client, from which the user can request the services and resources of the system displayed on a webpage.
II. a webserver together with a WSGI server (running our python code) taking the client's requests, serving, and performing the demanded operations.
III. a DBMS that handles and interacts with the Epicollect5 database through the Epicollect5 REST API and other databases such as OpenWeatherMap, OpenStreetMap, Google Map, Bing Map (final selection tbc)

2.2 USERS OF THE SYSTEM

The users of the proposed system have been classified into two groups:

1. **Passive users**:
   These include citizens of Lagos and Yaoundé, policymakers, urban planners, researchers, NGOs, etc., and anyone interested in the subject, who use the proposed web application for informational purposes of the local situation or the issue in general.

2. **Active users**:
   These include citizens of Lagos and Yaoundé, who actively contribute to the set of ALPhA spaces through Epicollect and use the proposed web application to extract specific information aiding their personal lives (such as accessibility, air pollution, injury risk, etc. of a certain ALPhA space) (and to communicate with the network of other active users).

2.3 DATASET

The web application will make use of the following three datasets gathered with and stored on Epicollect:

1. Lagos ALPhA study on public space exercise > 170 entries
2. Yaoundé ALPhA study on public space exercise (English version) > 130 entries
3. Yaoundé ALPhA study on public space exercise (French version) > 80 entries

The three datasets make up a total of 348 entries (last visited 20.04.21), 290 of which are georeferenced. All are collected via the same questionnaire of 19 questions (plus follow-up questions), resulting in data entries containing 74 attributes each. Most of these attributes however are results of follow-up questions, requests to elaborate or to proceed, etc., and can thus be overlooked.

2.4 FUNCTIONAL SPECIFICATIONS OF THE SYSTEM

The web page of the proposed system should offer the following functions:

1. **A mapping tool**: comprising a base map layer (OSM, Bing Maps, Google maps; tbc) displaying both cities, a layer of local hospitals, a layer of the user's location, and a layer of all georeferenced data nodes. The map will be a dynamic element with which the user can interact.
2. **At-a-glance-view (Dashboard)**: of the attributes of the marked ALPhA sites. In the map view of the data, the user can click on (or hover over, tbc) each data node to display a dashboard view of that node and its most relevant attributes as a pop-up window.
   The dashboard shall include:
   - the rating of the ALPhA spaces through the application users
   - an image
   - distance to the user
   - distance to the nearest hospital
   - observed indicators for any increased/decreased safety or injury risks
   - information on the nature of the exercise best to perform here and how it is organized (do groups meet here regularly or do individuals come spontaneously?)
3. **A data analysis tool**: The application of various filters will allow the user to display subsets of the data, based on their personal needs. The data nodes can be filtered by; type of exercise, injury or safety risk, lockdown use, distance to the nearest hospital, etc., and are then again displayed in map view with the at-a-glance pop-up option.
4. **Individual presentation of data**: In the map view of the data nodes (filtered or unfiltered) the user can select a node (by clicking it) and is redirected to a more extensive page of that ALPhA space, displaying more detailed information than the Dashboard-view. Additionally, each page will provide the user with the possibility to rate the ALPhA space (via a star rating system out of 5) together with a comment section, which may be used for posting information not collected through Epicollect5 yet or for the coordination of organized group exercises.
5. **A dynamic element** of the page updating and displaying the current weather forecast for the day.
6. **An incentive to contribute**: The webpage will contain a section where the user shall receive further references and information on the objective of the ALPhA study and on the organizers (Urban Better | Oni et al.) to better convey the prevailing issue and the possible solution. Furthermore, the user shall receive instructions on how to contribute to the dataset of ALPhA spaces using Epicollect5.

2.5. ASSUMPTIONS

The system will be designed under various assumptions and depends on several factors, being the following:

Assumptions

- The georeferenced ALPhA spaces are in fact public (i.e., no private owner)
- The citizens reporting on the space are honest in their evaluation of injury and safety risks (since its verification is outside the scope of this project)
- Epicollect5 will continue to grant access to its database through its REST API

Dependencies

- The quality of displayed data, i.e., the multiplicity and quantity of detailed information on the ALPhA sites depends on the engagement of the Epicollect5 users with the questionnaire
- The accuracy of the collected data points on Epicollect5 depends on the GPS accuracy of the user's mobile device at the time of the upload.

2.6. RELEVANT PHENOMENA:

phenomena	Shared, machine, world	Controlled by
User registration	shared	world
User login	shared	world
User creates custom views (filtering)	shared	world
User adds comment	shared	world
User's comments stored in database	machine	machine
User rate the software	shared	world
User's rating stored in database	machine	machine
User logout	shared	world

3. REQUIREMENTS

3.1. FUNCTIONAL REQUIREMENTS ("SHALL LIST")

The web application should meet the following functional requirements:

- The system shall be developed in Python.
- The system shall display web pages by the means of HTML code and CSS.
- The system shall use either OSM, Google Maps, or Bing Maps (tbc) as the base map for the multi-layered interactive mapping tool.
- The system shall retrieve data from Epicollect5 using its REST API
- The system shall access data from the Epicollect5 database, either in real-time at every user request or with intermediate storage of the data in another database (tbc) to uphold service, even when the Epicollect5 database is down or cannot be reached.
- The system shall allow users to query and visualize data according to their needs (location, type of exercise, etc.) i.e., provide data analysis by the means of filters.
- The system shall allow users to interact with the data by the means of a rating system and a comment section for each data point.
- The system shall allow users to register with a username and password.
- The system shall allow users to log in and log out.
- The system shall, ask for and then capture the user's location (create a cookie for the user session) to provide customized data visualization.
- The system shall provide the distance and shortest way from the user to a georeferenced ALPhA space
- The system shall provide the distance from each ALPhA space to the nearest hospital
- The system shall display the location of the user in map view
- The system shall provide information on the current local weather, by calling data from OpenWeatherMap (tbc)
- The system shall contain a static section hosting guidelines on how to use Epicollect to contribute to the project, information, and further references on and around the ALPhA study and its organizers. The section shall also direct the user to the Epicollect website, the UrbanBetter website, and the social media channels of the ALPhA study via hyperlinks.

3.2. NON-FUNCTIONAL REQUIREMENTS

3.2.A. PERFORMANCE

The web application will be synchronized with the Epicollect5 database (whether in real-time upon each user request or with an intermediate step of data storage in another database, tbc). Thus, any changes that are being performed via the Epicollect5 platform shall be represented in the web application. Moreover, the system shall provide feedback to its users in no more than 5 seconds and should be available 24/7.

3.2. B. RELIABILITY

The system must obtain a certain level of security since anyone is allowed to register. It must always display the same information as what is uploaded to Epicollect5, without the risk of possible alteration by an external source, jeopardizing data integrity. The comment section represents a special vulnerability of the system in terms of security and shall be restricted to a certain size that can be posted, to avoid attackers storing unreasonable amounts of data in our system via the comment section to induce a slowing or shutting down of the application, decreasing its reliability.

3.2. C. INTERFACE/USABILITY

The user shall interact with the system application through a website, composed of HTML web pages of static and dynamic nature. Personal computer penetration in both Nigeria and Cameroon is low and most people access the internet through mobile devices. A clean, compact, and intuitive user interface to suit small screens shall therefore be adopted by the system. The language of the web pages is chosen to be English.

4. SYSTEM MODELS

4.1. USE CASE MODELS

Use cases describe the functional requirements of a system from the end user's perspective, creating a goal-focused sequence of events that is easy for users and developers to follow.

UC1: Registration

1. The user selects the “register” option from the start page
2. The following screen asks the user to fill in the registration form, including username, email address, and age.
3. The user fills the form and confirms the process.
4. The username of the user is stored in the software’s database.
5. The user’s password is encrypted before being stored in the software’s database.
6. Exit condition: the software stores the registration information in the database.

UC2: Login

1. The user enters a username and password.
2. The software responds by verifying the user and either granting or denying access to the system.
3. Upon entry, the software creates a new user session, including cookies e.g., the user’s geolocation and username

UC2: Passive user

1. The user enters the main webpage after logging in
2. The system shows the default map view with all available data points that can be browsed by the user to learn more about the ALPhA sites (using only the dashboard view or exploring the individual pages)
3. The user can access the static elements on the main webpage to be redirected to external resources associated with the ALPhA study. Here they will also find instructions on how to contribute to the project using Epicollect.

UC3: Active user (custom visualization)

1. The user enters the main webpage after logging in
2. The default map view, containing all available data points can now be customized by applying filters based on their personal needs. ALPhA spaces can be filtered according to:
   - Nature of the exercise (Running or jogging | team sports | cycling | swimming | aerobics | other activities not listed | potential exercise space)
   - How exercises are done (individually | in groups | both)
   - Spaces that host organized activities | individual activities
   - Spaces actively used during lockdowns

- Spaces that increase the risk of injury or disease
- Spaces that decrease the risk of injury or disease
- Spaces with increased safety factors
- Spaces with decreased safety factors
- Maximum distance to a hospital
- Maximum distance from the user

3. The user can now display the customized data subset on the map, also featuring his location for better orientation and the current weather forecast for better planning.
4. The user can explore the customized data subset through the dashboard view only by hovering their cursors over the data points and receive the most relevant information on an ALPhA site at-a-glance, including rating, images, purpose, and navigational info, to better aid their choice in exercise space.
5. The user can also decide to explore the individual pages for each data point, to receive more detailed information and access the rating or comment section of the site.

UC4: Commenting

1. The user selects the “add comment” option on an individual ALPhA page
2. The software provides a field for user input
3. The user types in a comment
4. The software stores the comment in the database
5. The software displays the post on the message board of the ALPhA site
6. Exit condition: the user’s comment is successfully stored and displayed

UC5: Rating

1. The user selects the “add rating” option on an individual ALPhA page.
2. The software provides a field for user input, visualized as 5 empty stars
3. The user can hover over the desired number of stars, which animates them to be filled in, and click them as confirmation
4. The software stores the rating in the database
5. The software calculates a new average rating and updates it on the ALPhA page and dashboard
6. Exit condition: the new average rating is successfully updated and displayed

UC6: Logout

1. The user selects the “logout” button on the main page
2. The software requires the user to confirm the logout operation
3. The user confirms the operation
4. The software closes the user’s session, causing the session cookies to expire
5. The software returns the user to the starting page

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