Proposed Project: Waze for Museums

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Introduction

Rationale

Through an app, a visitor will plan a tour that would take them through a physical museum, visiting a set of pre-planned exhibits within a specific time limit. The app will identify routes that adapt to crowds and bottlenecks for the planned tour. The app will also provide narration on visited exhibits (e.g., audio, image, video annotations) pulled from a database for individual exhibits, and route guidance on how to navigate the museum. The desire here is to streamline the process of a museum visit optimizing one's time while taking a desired tour, all while providing an additional accessibility tool to those who are visually or auditory impaired.

Current Solution

A competitor product within the market is a brand called Navigine which offers museums an indoor navigation system which simply navigates users through the museum but does not take into account the congestion or large populations of guests within the museum. Our solution will utilize guests' locations to effectively route an individual past congestion areas and to improve overall flow of guests within the museum.

Terminology

Waze: A community driven navigation application which relies on crowdsourced navigation data to determine the best route
RFID: RFID (radio frequency identification) is a form of wireless communication that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency portion of the electromagnetic spectrum to uniquely identify an object, animal or person
BLE: Bluetooth low-energy devices – a form of wireless personal area network communications technology commonly found on phones and embedded systems.

Non-Goals

Aggregating data or collecting personal information about individual users.
Non-museum settings
ETAs, and time tracking

Proposed Design

Our system will use a combination of RFID tags and scanners and BLE devices. The RFID tags will be placed on exhibits and parts of exhibits, and the BLE devices will enable navigation to the exhibits. These two technologies will be complementary to realize the fine-grained and coarse grained indoor positioning necessary for the application.

RFID:
Our system will make use of RFID tags on exhibits and RFID scanners to identify exhibits respectively. RFID tags will be fixed to these points of interest and will serve as unique

identifiers for the system and will be one source of information about user location. Users will be given a small device (user device - UD) containing an RFID scanner on entry into the museum. These RFID scanners will constantly scan for RFID tags and will periodically contact a central server to resolve the RFID lookup and location association. The mobile application can then display media and information to the user about what specific exhibit they are interacting with. The central server will also provide routing and map information relevant for navigating within the museum and to the next location on a tour. The UDs will be collected from the user upon exiting the museum.

Bluetooth Beacons:
By using BLE sensors our system will passively locate and detect the transmissions of BLE devices. BLE will be included in the UD package. By strategically placing Bluetooth beacons throughout the area, these beacons emit signals detectable by nearby UDs. As devices communicate with these beacons, our system measures the signal strength of these interactions. Through signal processing algorithms, we convert these signal strength readings into actionable data, enabling us to precisely estimate the number of devices present in the room and to localize participating UDs.

Role of Server and Database:
A central server will collect information about the location of user devices over time and will provide routing information to help a user navigate through a set of tour stops. Minimally the database will realize UD localization based on BLE data (through multilateration and beacon location lookup), and by a table associating RFIDs with locations. The database will capture a time series of UD locations supporting quantification of how busy each gallery or exhibit is in the museum, and subsequent routing to meet time-based tours through a set of exhibits. Finally, the server will host maps delivered to a phone-based app to achieve turn by turn navigation of the user interface. Links to specific exhibit content will be pulled directly from URLs provided for each exhibit.

Smartphone App:
The smartphone app is intended to provide the user interface for tour selection, routing planning, map display, directional routing. It also serves to display associated multimedia presentations linked to the RFID tags on the various exhibit locations. The smartphone will incorporate the use of visual overlays on the observed scene (as XR) as appropriate for context. For example, the use of navigational cues steering a visitor to the next exhibit on a tour. These will be realized using features available to the phone operating system but developed to be cross-platform to the extent possible by using WebXR as the working framework. The smartphone app will leverage network access (either cellular carrier or local WiFi) to gain access to a local IP-based network.

System Architecture

See attached slide deck.
Waze Overview 2023-08-25.pdf

Impact

Security Requirements
Our goal is to minimize any personally-identifiable information collected to the extent possible while meeting the function of the application. To this end, we plan to create a custom user device (UD), separate from a user's smartphone, which is registered with the system. The UD will have a QR code that is scanned by the smartphone as the provisioning step to initiate the smart phone app. The system will subsequently track the assigned UD and send the UD's location to the smartphone app.

Costs
The ballpark costs for the system are:
Beacon: ~$20, ~4 per gallery (room)
RFID reader: ~$6 per user device
RFIDs: ~$0.5 per tagged exhibit
Server: ~$500

We intend to do a complete hardware design of the user device (UD) incorporating a rechargeable battery, BLE, RFID reader, and any input/output functions (buttons, LEDs). The fixed positioning beacons may be adopted if suitable open source devices can be identified for purchase.

Supporting Articles
https://www.mokoblue.com/bluetooth-indoor-positioning-system/