Spelman College Self-Guided Tour System: A Systems Engineering Approach

Spring 2023

Research Day

The Need for Preservation

- Historic Preservation has been described as "a conversation with our past, about our future"
- What is important about our past?

What lessons can we learn from the past to aid and/or enrich our knowledge of the present?

- What can we preserve for the future?

Spelman College is a Cornerstone of the Atlanta University Center, and its landmarks tell a rich and vibrant story that should be available for all visitors

- Who is the solution for?

This could serve incoming freshmen or people considering attending, alumnae, parents, and other visitors

Objectives

This project aims to aid in the presentation and preservation of Spelman College (and Atlanta University Center) history through:

1. Automation, and the use of modern, accessible, inexpensive technological tools;

2. The collection of and digitization of both oral and written historical records;

3. The personalization and enhancement of an activity aimed at providing facts, knowledge, and deep engagement to provide a curated experience to users of the system

Background

Manual Navigation vs Self-Guided Navigation

Several locations exist that provide visitors with the ability to conduct “self-guided” tours.

Example: When visiting some museums, visitors can purchase and use a system consisting of a small audio (or video) device and headset. When the device is in close proximity of a given artifact (or exhibit), the device will present facts about the given artifact/exhibit, thus allowing the visitor to proceed through the museum at his/her own pace, and reducing the need for an in-person or active “tour guide”.

Background (cont'd)

At Spelman College, no such system exists.

- Visitors may schedule a tour (in advance) with a College Ambassador, but no system exists that would allow potential visitors (alumna, future students, donors, etc.) to tour the campus at his/her own pace, if desired.

Task: Design a self-guided tour system for visitors to Spelman College

Use Cases

Use Case 1: Navigation via Sensors ("Smart Tags"):

Design a system that utilizes smart tags (sensors) and a smart tag reader

There are several guideposts at the College denoting points of interest.

Integrate smart tags/sensors with the guideposts such that, when the reader comes in contact with the sensor, the system provides facts about the given point of interest

Use Cases (cont'd)

Use Case 2: Location-based Navigation

Design a system that utilizes location-based data coordinates (latitude/longitude)

The coordinates of each point of interest at Spelman College would be captured and cataloged (in a database)

When the user's system arrives at the coordinates of a cataloged point of interest, the system provides facts about the given point of interest

Project Development Team

- Team 1
  - Hunter Christopher: Team Lead
  - Mika Campbell: Programmer
  - Skye Jackson: Lead Programmer
  - Shamira-Mare' Maxwell: Speaker
  - Kristen Mosley: User Experience Designer
  - Gabriela Ortega: Project Manager
  - Sydney Rouse: Tester
  - Jasmine Singleton: Programmer, Marketer
  - Mia Williams: Programmer

Team 2

Kyleigh Brown: Project Leader, Programmer

Jasmine Edwards: User Experience Designer, Programmer

Natalia Graham: Programmer

Jael Mackell: Project Manager

Jada Mason: Programmer

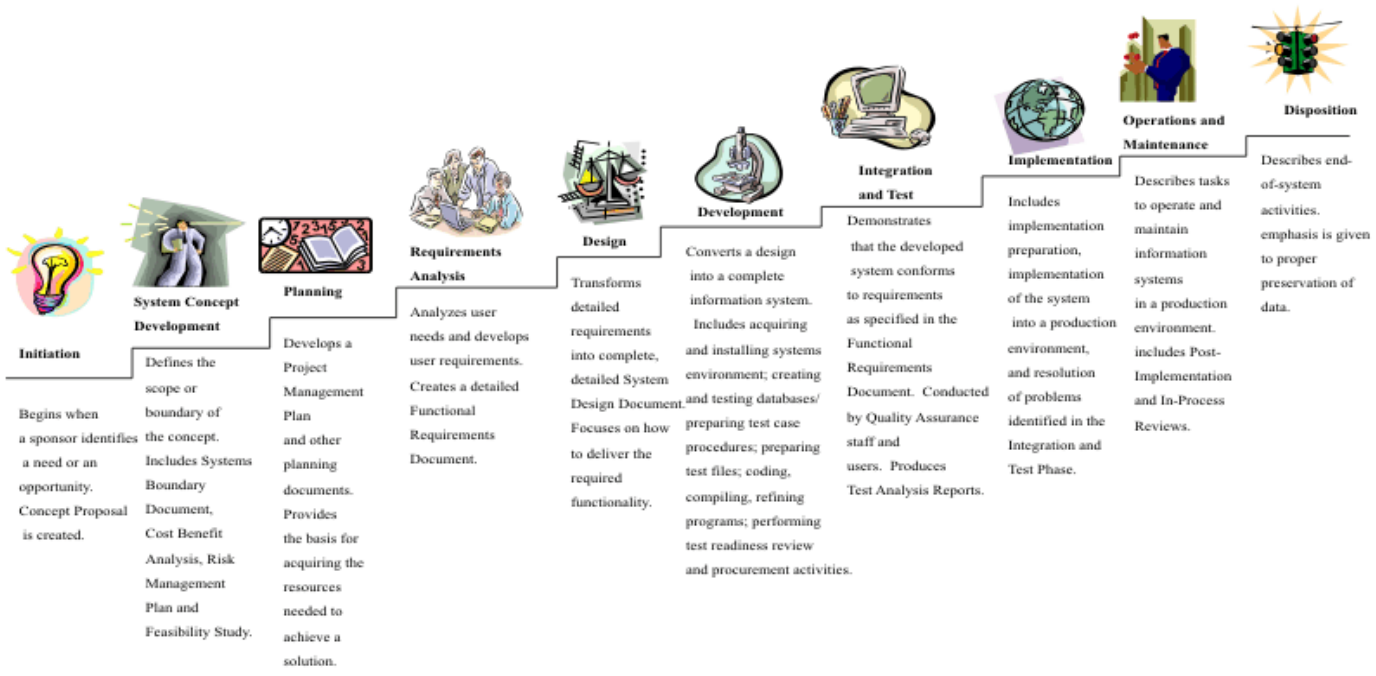
Sharon Onyancha: Customer Service Rep

Janiya Richardson: Marketing, Programmer

Lauren Waller: Technical Writer

The Systems Engineering Process

Systems Development Life Cycle (SDLC) Life-Cycle Phases



Process (Planning)

The System Development Team shall:

- Research hardware/software configurations
  - Considerations: Size, Usability, Portability
- Explore methods for gathering data from and interacting with smart tags
- Explore methods for gathering real-time location-based data
- Research efficient and effective ways to display and present the data to the user

Process (Planning cont'd)

Points of Interest Identified

- Suites
- Milligan
- Rockefeller Hall
- Sister's Chapel
- Wellness Center
- The Alumnae Arch
- Reynold's Cottage
- LLCI
- LLCII
- Manley/Science Center/Tapley
- Bessie Strong
- MacVicar
- Cosby
- Laura Spelman
- Giles Hall
- Parking Deck
- Packard
- Abby
- HH
- Manley Dorms
- Bookstore/Post Office

Process (Requirements Analysis)

- Project Plan Development
- Cost/Schedule/Performance
- Project Timeframe: 2/9/23 - 4/5/23
- Two Project Teams -> Two parallel design processes
- Budget: $10k
- Project Success = Successful design and implementation of a system that meets all requirements, within budget, and within schedule
- Risk Mitigation Planning
- Disaster Recovery/Contingency Planning

Process (Design)

Raspberry Pi 4 Model B (Open Source, Single Board Computer)

Pros

Full Fledged Computer

Many Operating System Choices

Large number of software applications available

Can use variety of programming languages (Python, C/C++)

Cons

On board memory is limited

Requires external input/output devices (keyboard, mouse, monitor)

Arduino Uno (Open Source, Microcontroller Board)

Pros

Relatively Inexpensive

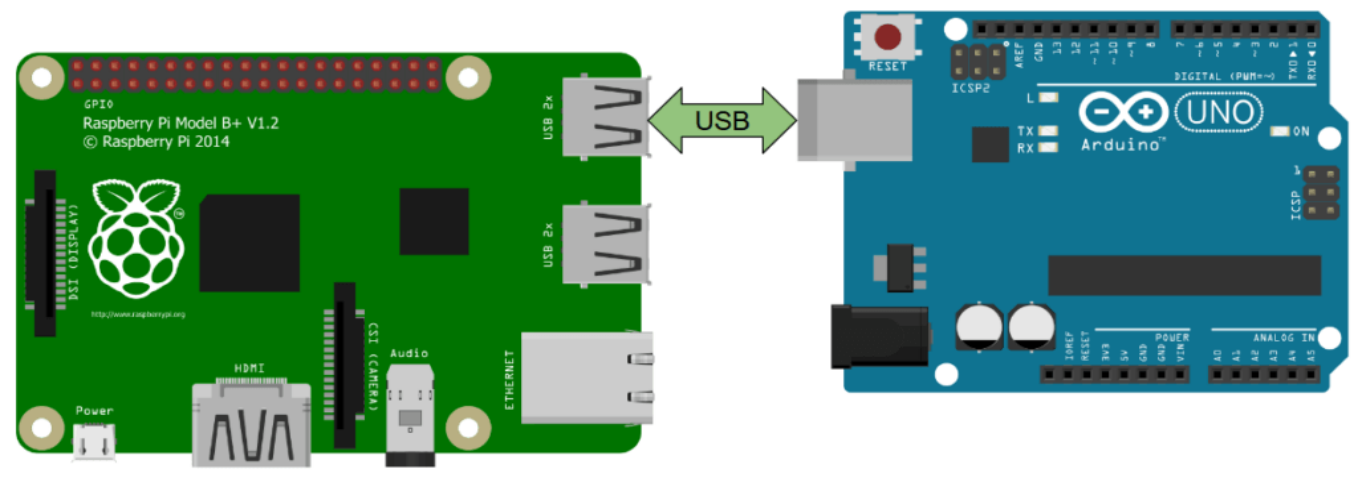
Small, lightweight

Cons

Can only store one program at a time, that must be uploaded to the device

Limited Processing Power

Doesn't natively support wireless connectivity



Process (Design cont'd)

Hybrid Design

- Connect the Arduino Uno and Raspberry Pi via USB
- Gather RFID data using Arduino Uno
- Send the data via Serial Communication from Arduino Uno to Raspberry Pi
- Control Self-Guided Tour via Raspberry Pi

Process (Testing)

System Design utilizing Raspberry Pi 4 Model B and RFID Reader Only

Raspberry Pi RFID reader system failed to work properly

Possible causes:

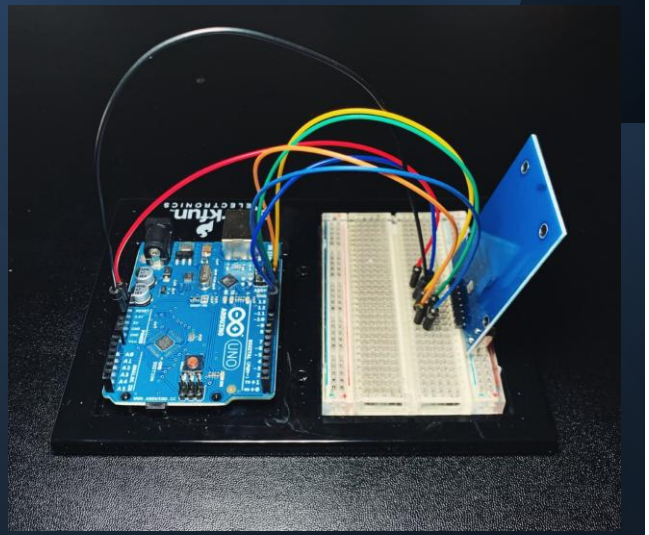
- Faulty RFID reader or bad connectors (connectors had to be soldered to the reader)
- Faulty Wiring
- Faulty Breadboard
- Errors in the coding of the RFID Raspberry Pi driver software (written in Python)
- Errors in the communication bus (Raspberry Pi utilizes Serial Peripheral Interface (SPI) to communicate with the RFID reader)

Process (Testing cont'd)

Troubleshooting Steps:

- Systematically tested each part of the system to pinpoint which component/subsystem led to the failure
- Wired the same RFID Reader, sensors, and breadboard using an Arduino Uno, and the system was able to produce Serial output
- Root cause of the System Design 1 issue: Failure of the MFRC22 RFID Reader to communicate with the Serial Peripheral Interface (SPI) bus on the Raspberry Pi
- We were able to recreate the SPI communication issue using four (4) additional new-in-box RFID readers and sensors; all four worked with the Arduino Uno, and neither worked with the Raspberry Pi alone.

Process (Testing)



System Design utilizing Hybrid Solution (Arduino Uno and Raspberry Pi)

- Testing using the Hybrid Solution was a success
- RFID reader was directly connected to the Arduino Uno via breadboard
- Driver software was created to collect RFID sensor data directly from the Serial Interface of the Arduino Uno
- Data was then sent to the Raspberry PI via direct USB Serial connection
- Driver software was used on the Raspberry Pi to conduct the self-guided tour

Demonstration

Conclusion

- The Development Team was able to successfully create and demonstrate a framework capable of providing an automated, curated, historical user experience

Future Exploration

#1: Navigation via Computer Vision (CV)

- Explore the use of navigation using a video-capable peripheral (Raspberry Pi Camera, etc.) in addition to (or in place of) physical sensors/tags/location-based data
- Solution combines Computer Vision, Artificial Intelligence, and Machine Learning to train the system to recognize objects/landmarks/points of interest
- Several useful Real-World applications:
  - Could aid in orienting or re-orienting usersin case they become lost
  - Could aid first responders and emergency personnel in tracking/locating, possibly leading to modest reduction in response time

#2: Integration of Virtual Reality (VR) Component with Self-Guided Tour system

- The use of Virtual Reality could provide a much more immersive experience for users of the system by recreating historical landmarks and architectures (Imagine seeing and experiencing a recreation of Spelman College during key moment's in its history)

#3: Integration of Augmented Reality (AR)

- Through the use of Augmented Reality, users can interact with famous historical figures, and Spelman Alumnae, both past and present, adding enrichment to the tour of the Crown Jewel of the Atlanta University Center.

Appendix

Outline

- Background
- Use Cases
- Project Development Team
- Process
  - Planning
  - Requirements Analysis
  - Design/Implementation
  - Testing
- Demonstration
- Conclusion
- Future Exploration

Process (Planning cont'd)

Research options for powering the system

- Batteries? Solar? Other means?

Research methods for providing network connectivity to the system

- Wi-Fi (if available)? 4G? 5G?

Research database options for storing and cross-referencing latitude/longitude (coordinates)

Research options for providing point of interest facts

- Pre-recorded audio files? Text-to-speech?

Process (Implementation)

Process (Implementation)

Software Configuration:

Install Python 3 (Raspberry Pi)

Install Python Serial Library on Raspberry Pi

RFID Arduino Library

Custom RFID Arduino Driver Code (serial_test.ino)

Custom Raspberry Pi Driver Code to read Serial Data from Arduino Uno

Process (Design cont'd)

Hardware Required:

(1) Raspberry Pi 4 Model B

(1) Raspberry Pi 4 Model B Power Supply (USB C cable)

(1) Arduino Uno Rev 3

(1) Micro SD Card (32 GB or above)

(1) MFRC22 RFID Reader

(1) Breadboard

(7) Male-to-Male Jumper Wires

(1) HDMI-capable External Display

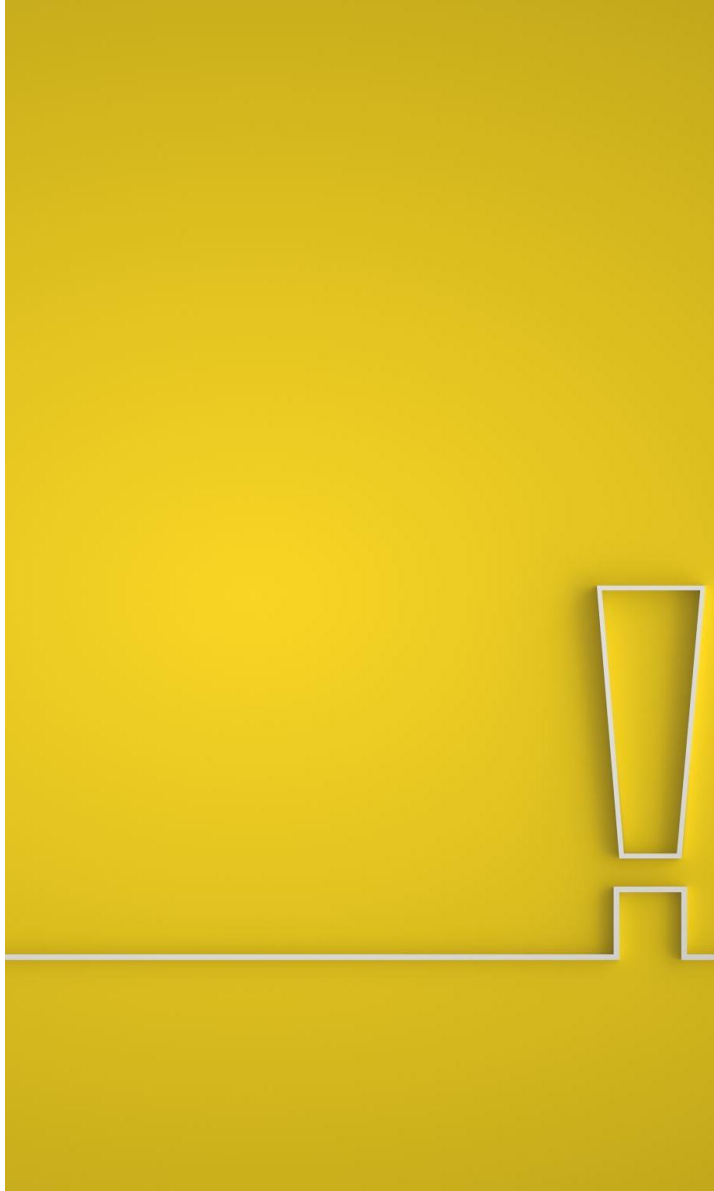
(1) Keyboard

(1) Mouse

(1) Usb Cable

(1) Mini HDMI to HDMI Cable)

(14) RFID Tags/Sensors



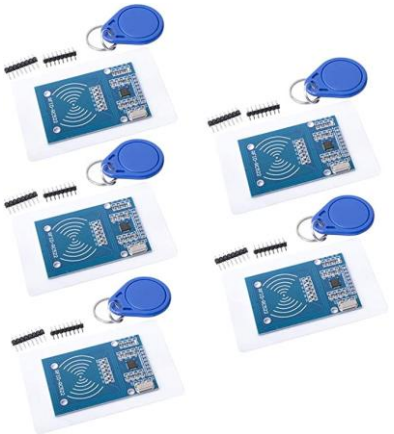
MFRC22 RFID Tech Specs

Power: 3.3V

Frequency: 13.56 MHz

Price: $3

Total cost for each system : $65



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