Culture Tour Final Report

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Abstract

The decline in public interest in traditional cultural heritage calls for innovative approaches to rekindle engagement. This report presents the development and enhancement of the Culture Tour, an AI-driven, location-based augmented reality (AR) game aimed at making cultural heritage exploration interactive and engaging. The project integrates advanced AI technologies, such as object detection, generative AI, and player analytics, to enhance user experience and educational value. Collaboration with tourism and game design students ensured a multidisciplinary approach, combining storytelling, game mechanics, and cultural knowledge. Key contributions include improvements to the object detection pipeline, enabling local model deployment for reduced latency, and the incorporation of generative AI for creating immersive narratives and rewards. Using the CRISP-ML(Q) methodology, the project iteratively addressed business understanding, data engineering, model development, and testing. The final deliverables included a toolkit of AI-driven components, comprehensive documentation, and a launch-ready presentation. These tools improve the game's scalability, user engagement, and cultural impact, laying a solid foundation for future iterations. This report reflects on the challenges, methodologies, and outcomes of this collaborative endeavor to bridge culture and technology.

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1. Introduction

A new game, Culture Tour, uses AI and augmented reality to show people cultural heritage in a fun, new way. Older methods for learning about cultural history frequently fail to engage a meaningful number of modern audiences who are adept at using technology. This project powerfully merges advanced augmented reality (AR) technology and advanced artificial intelligence (AI) to produce a remarkably interactive and deeply engaging platform that brings history to life. Gamified exploration, coupled with compelling storytelling, allows players to interact with cultural landmarks in a deeply new manner, cultivating a considerably deeper appreciation for heritage while simultaneously enjoying a highly entertaining as well as educational experience.

1.1 Project Background

The Culture Tour game helps people today connect with customary culture. Today's tech age sees an important number of conventional educational tools failing to effectively engage at least a large portion of users, thereby leading to a decrease in interest in cultural preservation. This project tackles this issue by providing a novel mobile gaming experience that deeply engages an important number of players in the wealthy cultural legacy of Saint Martin and the many historical sites of Utrecht.

This game uses several advanced AR technologies and at least three AI-driven object detection systems to provide a compelling combination of storytelling and exploration. By scanning objects with their smartphones, players unlock incredibly detailed historical animations and deeply wealthy narratives, thus creating a considerably enhanced, interactive learning experience. This project, constructed using Niantic's Lightship platform, along with integration with Europeana's wide-ranging digital archives, is a revolutionary attempt in preserving at least several thousand pieces of cultural heritage for a meaningful number of tech-savvy audiences.

Designed as a collaborative and iterative initiative, the project allows new teams each year to build upon prior achievements, integrating advanced technologies and expanding the game's cultural scope. This approach ensures continuous innovation and development, creating a sustainable platform that aligns with the evolving preferences of modern users while preserving historical narratives for future generations.

1.2 Business Case

The **Culture Tour** project addresses the declining public engagement with cultural heritage by delivering an interactive and educational AR gaming experience. Focused on the story of Saint Martin and Utrecht's historical landmarks, the game merges adventure with storytelling to captivate modern audiences and enhance their retention of cultural knowledge.

Key objectives include:

- **Promoting Local Tourism**: Encouraging visits to cultural sites by offering engaging narratives tied to real-world locations.
- **Fostering Community Participation**: Creating a shared experience that connects players with their cultural heritage.
- **Gamified Learning**: Utilizing interactive gameplay to enhance information retention and make learning enjoyable.

With quantifiable goals, such as achieving 3,000 monthly active users and increasing interactions with cultural content, the project not only preserves cultural heritage but also establishes a benchmark for creative educational entertainment. The integration of Europeana's archives ensures the game's educational depth, while its scalable design supports the addition of diverse cultural narratives in future iterations.

The **Culture Tour** initiative exemplifies how innovative technologies can transform the way cultural history is preserved and shared, making it relevant and accessible to contemporary audiences.

2. Methodology

The methodology for the **Culture Tour** project is structured to ensure a systematic and iterative approach to developing an AI-driven, AR-based game. Following the CRISP-ML(Q) framework, the process incorporates business understanding, data exploration, model development, and evaluation phases. This approach not only aligns with the project's technical goals but also ensures compliance with ethical standards and user-centric design principles.

2.1 Data Collection

Data Sources

1. **On-Site Photography**:
    - **Collection Process**:
        - Images are, focusing on reliefs, statues, and architectural elements associated with Saint Martin's story.
        - Professional and mobile cameras were used to replicate real-world scenarios in which users might interact with the game.
    - **Conditions**:
        - Images were taken under different lighting conditions (e.g., morning, afternoon, and evening) to simulate natural variations.
        - Multiple viewpoints were considered:
            - **Angles**: High, low, and side perspectives to improve object recognition across diverse user scenarios.
            - **Distances**: Close-up shots for detail and long-range shots for spatial context.
        - Efforts were made to capture both isolated objects and those within complex backgrounds to enhance the model's adaptability.
2. **Europeana Archives Integration**:
        - Digital artifacts from Europeana's extensive cultural heritage database were included to provide historical context and enrich gameplay.
3. **Demo Dataset**:
    - **Purpose**:
        - A curated dataset specifically designed for testing gameplay mechanics during a DEMO in Breda.
    - **Composition**:

        - Included 1,140 images across seven categories: Museum Gate, Watch Tower Remains, Tobias and the Angel, Begijntjes, Dancing Lamb Statue, Begijnhof Statue, and Museum Wall.
        - These categories represented key landmarks and objects that players would interact with in the AR game.
    - **Preparation**:
        - Images were carefully labeled and organized into training and testing sets to streamline the model development process.

Quality Assurance

1. **Manual Review**:
    - Each image was reviewed to ensure it met quality standards for:
        - **Completeness**: Images must fully capture the object without cropping out critical features.
        - **Accuracy**: Images were cross-referenced with their labels and metadata to ensure correct categorization.
        - **Relevance**: Only culturally significant objects directly tied to the game's narrative were included.
2. **Data Augmentation**:
    - **Techniques**:
        - **Cropping**: Focused on essential object details while removing unnecessary background clutter.
        - **Rotation**: Simulated varying angles of interaction to make the model robust to perspective changes.
        - **Brightness Adjustments**: Enhanced model tolerance to overexposed or underexposed conditions.
    - **Purpose**:
        - Augmentation was applied to smaller datasets to expand their size and improve model generalization.
        - Augmented images ensured the model could handle variations in user interactions, such as scanning objects in low-light conditions or from unconventional angles.
3. **Balancing the Dataset**:
    - Categories with fewer images were supplemented through augmentation or additional on-site photography to balance the dataset.

- This ensured equitable representation of all object types during model training.

2.2 Approach

The project adopted a multidisciplinary approach, integrating data science, AR technology, and user experience design to create an engaging and scalable game.

Key Steps:

1. **Business Understanding**:
    - Collaborated with stakeholders to define objectives, including preserving cultural heritage and engaging modern audiences.
    - Mapped user needs to technical solutions, focusing on AR interactivity and educational value.
2. **Data Understanding**:
    - Conducted exploratory data analysis (EDA) to assess the quality, distribution, and diversity of collected images.
    - Established clear data preparation guidelines to ensure consistency and relevance.
3. **Model Development**:
    - Implemented GhostNet V2 for object detection and classification due to its lightweight design and high accuracy.
    - Fine-tuned pre-trained weights on curated datasets for optimal performance.
4. **Tool Refinement**:
    - Enhanced gameplay mechanics, such as the leveling-up system, to increase user engagement.
    - Integrated Europeana's database for real-time access to cultural content.
5. **Evaluation and Feedback**:
    - Tested the prototype with users to gather insights on functionality and educational impact.
    - Iterated on design and technical features based on user feedback.

3. Solution Design

3.1 Core features

The Culture Tour project incorporates advanced AI and AR technologies to deliver an engaging, educational, and interactive experience. Key core features include:

3.1.1 Object Detection and Recognition

- **Feature Description**: Object detection and recognition are central to the gameplay experience. Players interact with cultural artifacts in real-world settings by scanning objects using their smartphones. This triggers AR-based animations and narratives, enriching the storytelling experience.
- **Enhancements**:
  - Improved object detection model leveraging GhostNet V2 for lightweight and efficient classification.
  - Integration with Europeana's archives for detailed contextual information about scanned objects.
  - Real-time classification and feedback to ensure seamless gameplay.
- **Use Case Examples**:
  - A player scans a point of interest and the game displays an animation depicting a historical event associated with the POI.
  - A relief is scanned, unlocking a narrative segment tied to the cultural significance of the object.

3.1.2 Integration of Europeana's digital archives

- **Feature Description**: Seamless integration with the Europeana database enriches the game's cultural depth.
- **Functionality**:
  - Access to over a million digital artifacts to provide detailed historical insights.
  - Dynamic linking of detected objects to relevant archival entries.
- **Impact**:
  - Enhances the educational aspect of the game.
  - Broadens the cultural scope by allowing players to explore diverse narratives beyond Saint Martin.

3.1.3 Secrets of the Saint AR Game

The last core component we received from the previous team of developers was an AR Game. See Figure 6 for the main game loop, which was created by the previous team.
The game encourages the player to walk from POI (Point of Interest) to POI, while solving the AR puzzles and collecting items and objects related to Saint Martin. Every collected item gets saved to a Logbook, which also provides the player with a piece of the history of Saint Martin. There are currently six puzzles created, with three pairs of puzzles which upon completion, reward the player with a secret animation, also saved in the logbook when discovered.
As mentioned above, the players can take pictures in the designated menu for Image Recognition, which will send the image for detection with an API call. After processing the image, the player gets back the name of the object and description.

3.2 Applied Features

3.2.1 Technical details of object detection using GhostNet V2

3.2.1.1 Overview of GhostNet V2 Integration

- **Selection Rationale**:
    - GhostNet V2 is optimized for mobile and edge devices, offering high computational efficiency with minimal resource requirements.
    - Pre-trained on ImageNet, GhostNet V2 delivers high accuracy while reducing training time.

3.2.1.2 Architecture and Configuration

- **Architecture**:
    - GhostNet V2 employs a lightweight structure that uses Ghost Modules to reduce computational costs while maintaining feature richness.
    - Width multiplier set to 100% to balance computational efficiency and accuracy.
- **Input Processing**:
    - Images resized to 224x224 pixels and normalized using ImageNet statistics.

- Data augmentation techniques applied to increase model robustness (e.g., rotation, brightness adjustment).
- **Output Classes**:
  - Model trained on curated datasets encompassing key cultural artifacts such as statues, reliefs, and architectural elements.

3.2.1.3 Training and Evaluation

- **Training**:
  - Fine-tuned GhostNet V2 using PyTorch with pre-trained ImageNet weights.
  - Hyperparameters:
    - Loss Function: CrossEntropyLoss.
    - Optimizer: Adam, Learning Rate = 0.001.
    - Batch Size: 32.
    - Epochs: 5.
- **Evaluation Metrics**:
  - Achieved 100% training accuracy for the DEMO datasets.
  - Confusion matrix analysis to identify class-wise performance (Figure 1).
  - Grad-CAM and LIME applied for explainability, visualizing how the model makes predictions (Figures 2 and 3).

3.2.1.4 Model Deployment

After training and testing the PyTorch GhostNetV2 model, our task was to implement it into the game's Image Recognition pipeline. The pipeline enables players to take a picture of a point of interest - such as a statue, building, or other cultural heritage landmarks in Europe. The image is sent to the main model (SSD Mobilenet V1) for inference through an API call, where the object is identified and its name and description are returned.

- **Pipeline Design and Implementation**

The new pipeline is designed for efficiency. Instead of the initial API call, the lightweight model performs an inference locally. If the model's confidence score is high enough (≥70%), the name of the object is directly returned to the player. If the confidence is low, the image is sent to the API for inference using the more robust model trained by the previous team (see Figure 4 for the full inference pipeline).

This hybrid approach minimizes API calls, while optimizing the performance and resource allocation

- **Technical Challenges and Solution: PyTorch to ONNX**

The main challenge of this task was exporting the PyTorch model to another model format compatible with Unity, the game engine used to create AR Game, and C#, the programming language of the game. After extensive research, we determined that the ONNX (Open Neural Network Exchange) framework was the ideal solution for several reasons. Firstly, the ONNX framework is highly popular and it has native support for .NET Framework with the Microsoft.ML.OnnxRuntime NuGet package, allowing for fast integration into C# projects without needing any other dependencies. The second reason is that a PyTorch model can easily be exported to Onnx since PyTorch has a prebuilt function to exporting it's models to the Onnx framework, while preserving weights and ensuring the model performance is not deteriorating during the transfer. So, using ONNX for deploying a PyTorch model in C# makes the most sense since we value performance and seamless integration.

3.2.1.5 Benefits of GhostNet V2 Integration

- **Accuracy**:
  - Improved classification accuracy from ~97% (original models) to ~99%.
- **Efficiency**:
  - Lightweight design ensures low-latency inference suitable for mobile deployment.
- **Scalability**:
  - Modular architecture allows seamless integration with additional datasets or cultural contexts in future iterations.

3.2.2 Continuous Learning Pipeline

How it works

To ensure our model remains up to date, we implemented a Continuous Training Pipeline. This pipeline is designed to work using the existing API, which collects and stores data. The pipeline retrieves images from the BUas server, where they are stored after being uploaded via the API, and it gathers the annotations and the classes from the MySQL database. Once the data is collected, a training dictionary is made to link image paths and their corresponding annotations. The images are then preprocessed to match the input format expected by the model. After all the data is prepared and in the right format, the model is loaded and trained using the updated dataset. After training is complete, the model is exported to the ONNX format with a filename that includes the date of training. This ensures that each model version is clearly identified by its training date, making it easy to track and manage different versions. The trained model is then saved to the BUas server, ensuring the latest version is always available for inference and deployment.

Next steps

Since the current state of the API allows for checked and corrected labels, one of the intuitive steps for the future teams would be to get an expert to label all the pictures and correct their annotations, so that they can filter the data pulled from the database and the server to only include the best data. As of right now, there are only 2 images with corrected labels, out of all the saved ones.

The second step would be to truly transform it into a scheduled training pipeline, by applying a scheduler. Right now the API is not used that much to add new data and keeping it online all the time would be costly. This step is a good idea for a future where the app is used constantly and there is a new flux of data regurarly, which will make the models to easily get out of date or simply miss on the opportunity to improve on classes with less images as training material.

3.2.3 Leveling-up system Implementation

As part of enhancing player engagement, a leveling-up system has been integrated into the game's API. This system rewards players with experience points (XP) based on their actions within the game. The goal of this feature is to incentivize exploration, interaction, and learning, making the gameplay experience more engaging and rewarding.

XP Rewards System:

1. **Finding Objects:**
    - Action: Players earn 50 XP when they discover an object in the AR environment.
    - Example: Discovering a hidden artifact during a cultural tour.
    - Reason for XP Difference: Discovering objects is a core mechanic of the game and requires effort and exploration, which are crucial for advancing the storyline. Higher XP rewards encourage players to actively search for objects.
2. **Reading Information:**
    - Action: Players earn 10 XP for reading cultural or historical information related to objects they discover.
    - Example: Viewing an information panel about an ancient monument.
    - Reason for XP Difference: Reading information is supplementary to the gameplay. While it enriches the educational aspect, it doesn't require as much effort as finding objects, hence the lower XP reward.
3. **Interacting with AR Elements:**
    - Action: Players earn 30 XP for engaging with AR features, such as pulling a sword or solving an AR puzzle.
    - Example: Completing an AR task that unlocks a hidden story or completing a challenge involving object interaction.
    - Reason for XP Difference: Interacting with AR features is more effort-intensive and immersive than reading information but less effortful compared to finding objects. The mid-level XP reward reflects the balance of engagement and effort.

The leveling-up system is a crucial feature to enhance player engagement by incentivizing exploration, interaction, and learning within the game. The difference in XP rewards reflects the effort, immersion, and impact of each action on the gameplay experience. For instance, discovering objects awards 50 XP, the highest reward, as it is a core mechanic that requires players to actively explore and engage with the AR environment, driving the storyline forward. Interacting with AR elements, such as pulling a sword or completing a puzzle, awards 30 XP, recognizing the effort and immersion involved in these dynamic tasks, but slightly less than discovering objects since these interactions often occur after finding the object. Reading additional information awards 10 XP, the smallest reward, as it is less effort-intensive but remains valuable for enriching the educational aspect of the game. By aligning XP rewards with the level of effort and importance of each action, the system not only encourages players to engage with all aspects of the game but also provides a sense of progression and accomplishment, motivating them to explore more, interact with AR features, and learn about cultural heritage in an enjoyable and rewarding way.

Future steps for the leveling-up system could include a team of game developers fully integrating this feature into the gameplay loop, ensuring that players experience seamless progression and feedback while interacting with the game. Additionally, the flexibility of the system can be enhanced by allowing XP points to be easily adjusted through a configuration file, enabling future teams to fine-tune the rewards based on gameplay testing and user feedback. This adaptability will help maintain a balanced and engaging experience as the game evolves.

3.2.4 Demo APK Creation

Development of the AR Game Demo for Presentation

For this project, we developed a demo tour to showcase and explain the AR game experience at the request of our client, Jessika. The demo was specifically created for a meeting with representatives from the Spanish Embassy, aiming to present the product, engage stakeholders in the project, and secure additional funding for further development and research. The meeting revolved around the "Route of Saint Martin in Europe," which serves as the core theme of the game.

Planning and Route Design

To start developing the demo and to create the levels around the place of the meeting, the Stedelijk Museum in Breda, we had to find a suitable place and some points of interest. We chose the Valkenberg City Park for the scenery and abundance of cultural heritage, such as statues and structure remains. After discussing with our client and what she expects from this demonstration, we chose 4 locations and a route of approximately 15 minutes in the park. See fig 4.1 for the demo route.

The demo starts at the Stedelijk Museum Gate, then continues to the watchtower remains, the statue of Tobias and the Angel, and ends with the Begijntjes statue.

Technical Implementation

As mentioned previously in subsection "3.1.3 Secrets of the Saint AR Game", the game was developed using the Unity Game Engine, with the AR functionality provided by Niantic's ARDK. To integrate the selected locations into the game, we activated them with VPS (Visual Positioning System) status in Niantic Lightship's database and Geospatial Browser. This process required submitting a minimum of 10 3D scans per location, recorded at various times of the day and under different weather and lighting conditions, using the Niantic Wayfarer mobile app. The 3D scans consist of videos of maximum 5 minutes around the object of interest, made carefully using the app.

Once the locations were VPS-activated, each was paired with one of six puzzles and interactions created by the previous team. Additionally, we assigned a map marker (a 3D model) to each location to enable its visualization on the game's map. The scenes were built in Unity, the apk file was created and tested, and based on the tests, we made minor changes so the players will have a smooth gameplay. One thing we had to take into account was the order of the puzzles, since collecting one pair would reward the player with an animation. For example, to get the animation of Saint Martin and his well-known act of cutting the cape, the player has to collect both the sword and the cape, but it makes sense to have to collect the sword first and after collecting the cape, the player gets the reward animation.

The creation of this demo was greatly facilitated using the Unity Documentation provided to us by Rebecca, one of the students who worked on the project before us. The documentation aided us in understanding the process required to add new game scenes to the game.

3.3 Ethical Considerations

The project prioritizes ethical considerations to ensure compliance with data protection regulations and respect for cultural heritage. Key ethical aspects are integrated into the design and development process, focusing on data privacy, cultural sensitivity, and transparency. By fostering engagement with cultural experts, retraining algorithms for fairness, and planning for accessible privacy notices, the project ensures alignment with both legal and moral standards. In this project, the analytics translator reviewed GDPR compliance to ensure the implementation of robust data privacy measures. Meanwhile, our data scientist applied responsible AI techniques, which are detailed in the appendix. Finally, our data engineer contributed valuable feedback to further enhance the project.

3.3.1 Data privacy measures ensuring GDPR compliance

The project is designed to align with GDPR principles to ensure the protection and responsible handling of user data. Current measures include data minimization, where only essential data, such as location and gameplay analytics, is collected. All data is anonymized or pseudonymized before storage and analysis to prevent user identification. Secure storage is ensured through the use of SURF Research Drive, a GDPR-compliant platform with encryption and access controls to restrict unauthorized access.

Users are informed about data collection purposes, and mechanisms are in place for them to access, correct, or delete their data. However, future steps include implementing explicit consent mechanisms, providing detailed in-app privacy notices, and enabling users to grant or revoke consent easily. These steps will ensure users have greater control over their data and a clear understanding of how it is used.

A robust data retention policy ensures that personal data is only retained as long as necessary and securely deleted afterward. While a data breach response plan is not yet implemented, it is a planned development to address any potential incidents effectively. Transparency about data sharing with GDPR-compliant partners, such as Europeana, is an ongoing focus.

3.3.2 Future Steps Concerning Ethics

The project has laid a strong foundation for ethical, cultural, and data compliance considerations, but several critical steps remain to further enhance its impact and ensure alignment with its goals. Below are the key areas for future development:

1. User Transparency and Privacy

- Develop and integrate in-app privacy notices to clearly inform users about data collection, storage, and sharing practices, ensuring transparency and trust.
- Implement a user consent mechanism that allows players to grant, revoke, or modify consent for data collection and processing directly within the app.
- Provide an accessible data management interface where users can request access to their data, make corrections, or request deletion with ease.

2. Data Management Enhancements

- Finalize and implement a data breach response plan to swiftly detect, report, and mitigate security incidents, ensuring compliance with GDPR requirements.
- Establish automated data retention and deletion processes to securely delete personal data once it is no longer necessary for the project's purposes.

3. AI System Improvements

- Continue to retrain and evaluate AI algorithms to reduce biases and improve performance, ensuring fairness in the detection and recognition of cultural heritage objects.
- Introduce a bias reporting system within the app, allowing users to report inaccuracies or biases, which will feed into periodic system reviews for improvement.

4. Cultural and Educational Expansion

- Broaden the scope of cultural heritage narratives represented in the game to include underrepresented groups, ensuring diversity and inclusivity.
- Collaborate further with local experts and communities to validate and enrich the cultural content, maintaining authenticity and respect for cultural heritage.

5. User Engagement Features

- Fully integrate the leveling-up system into the gameplay loop to enhance engagement and motivate players to explore, interact, and learn. Ensure XP rewards are fine-tuned based on user testing and feedback.
- Add more interactive AR elements to provide dynamic and immersive experiences that encourage deeper exploration of cultural heritage sites.

6. Sustainability and Accessibility

- Explore methods to optimize the game's computational and environmental efficiency, minimizing the energy consumption of AI processes.
- Ensure the game remains accessible to a diverse audience by considering language localization, device compatibility, and inclusive design practices.

By addressing these future steps, the project can evolve into a more transparent, engaging, and socially responsible platform that aligns with its goals of cultural preservation, education, and user empowerment. These developments will ensure the project continues to grow while meeting ethical and technical standards.

4. Analysis and Evaluation

4.1 Impact on Business case

The features implemented in the Culture Tour project significantly enhance its ability to address the business case objectives by combining innovative technology with cultural preservation and educational engagement. These features directly contribute to achieving the key goals outlined in the business case:

Promoting Local Tourism

The integration of object detection using GhostNet V2 and Europeana's digital archives encourages players to visit real-world cultural sites. By linking gameplay to physical landmarks and historical objects, the game creates an immersive experience that draws players to these locations, thereby driving foot traffic and increasing awareness of cultural heritage. The seamless blend of storytelling and AR gameplay transforms these sites into interactive spaces, making cultural tourism engaging and memorable.

Fostering Community Participation

Through features like the leveling-up system, the project encourages players to actively participate in cultural exploration and connect with their heritage. By rewarding actions such as finding objects, interacting with AR elements, and learning about history, the game fosters a shared sense of purpose and cultural appreciation. These mechanics also encourage community discussions and shared experiences, further deepening the impact of the game on local and global communities.

Gamified Learning

The combination of object detection, AR interactions, and the leveling-up system turns learning into a fun and rewarding experience. Players are motivated to engage with educational content, as the XP rewards provide a tangible sense of progress and accomplishment. This gamified approach improves information retention, making cultural and historical knowledge more accessible and appealing to modern audiences.

Quantifiable Goals

The project directly supports achieving measurable targets, such as reaching 3,000 monthly active users. By integrating features like real-time object recognition, enriched storytelling, and engaging progression systems, the game creates a compelling reason for players to return regularly. The inclusion of Europeana's extensive archives also broadens the cultural content available, increasing interactions with historical narratives and supporting long-term user retention.

Scalability and Future Potential

The technical foundation of the project, including GhostNet V2 and the scalable leveling-up system, allows for seamless expansion into other cultural narratives beyond Saint Martin. This flexibility ensures that the game can adapt to future demands and incorporate diverse cultural stories, broadening its appeal and reinforcing its value as a tool for cultural preservation.

Appendix

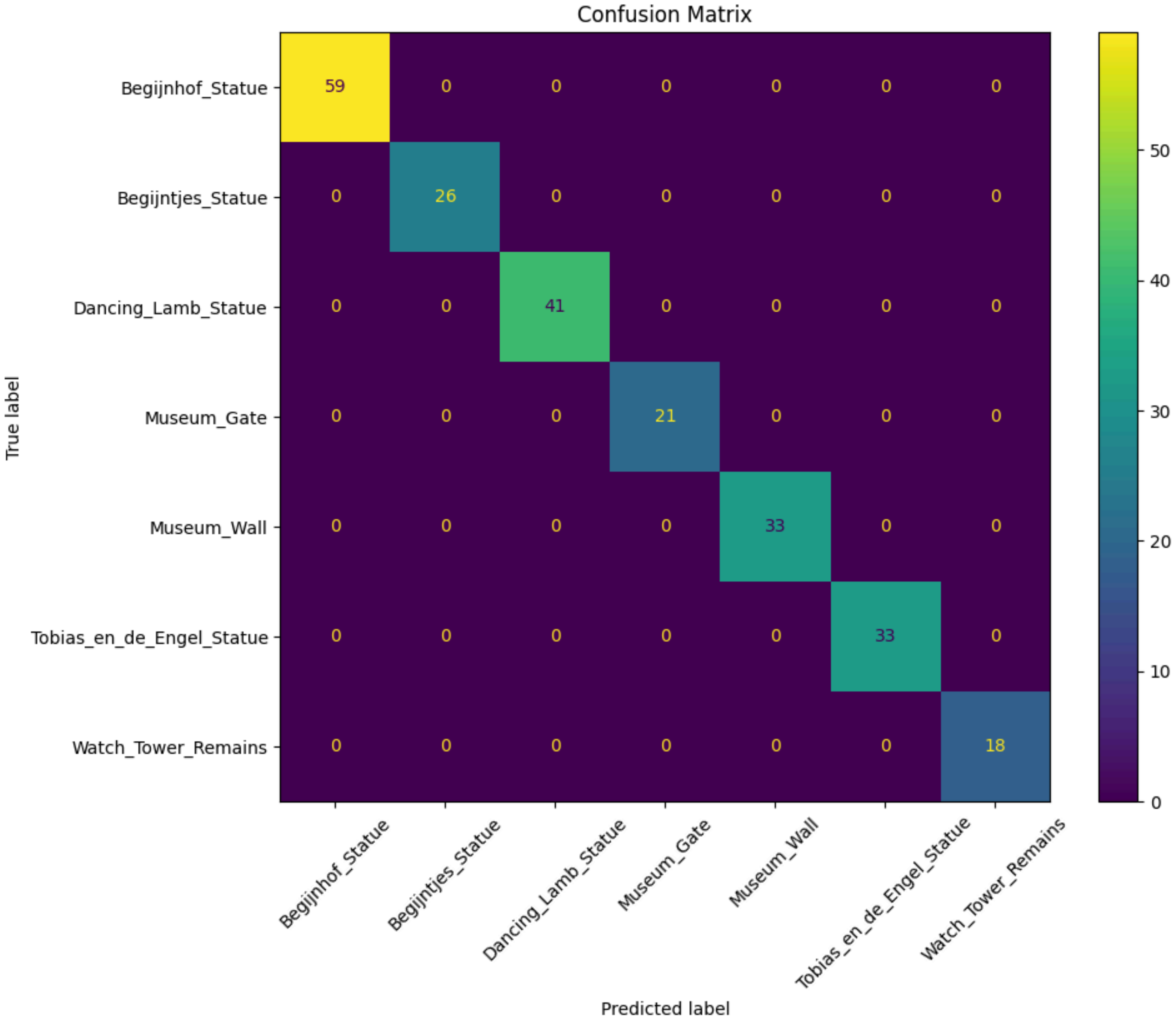

Figure 1 - Confusion Matrix

Figure 2 - Grad-CAM explainable AI technique

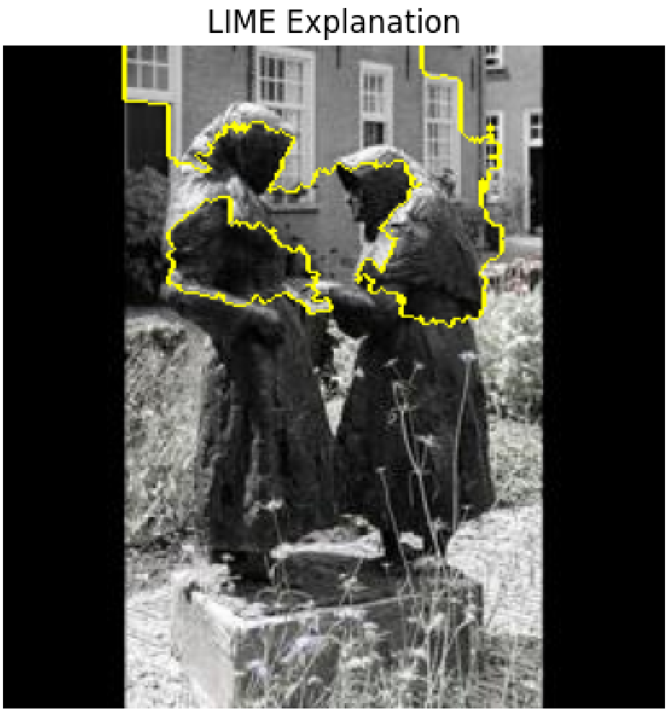

Figure 3 - LIME explainable AI technique

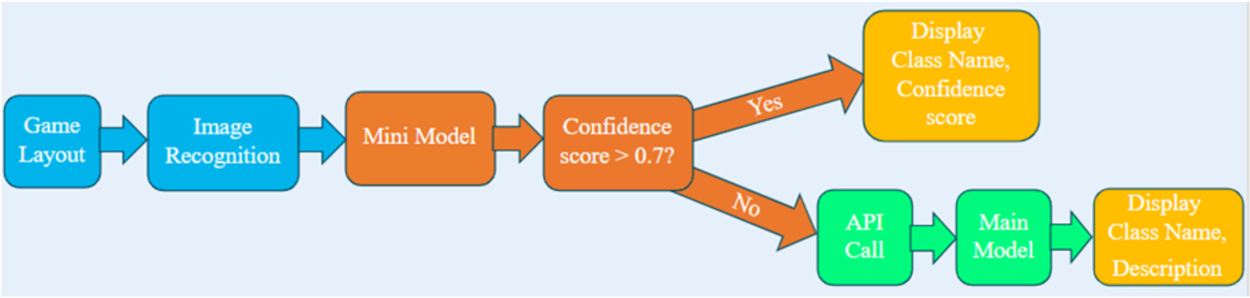

Figure 4 - The Inference Pipeline

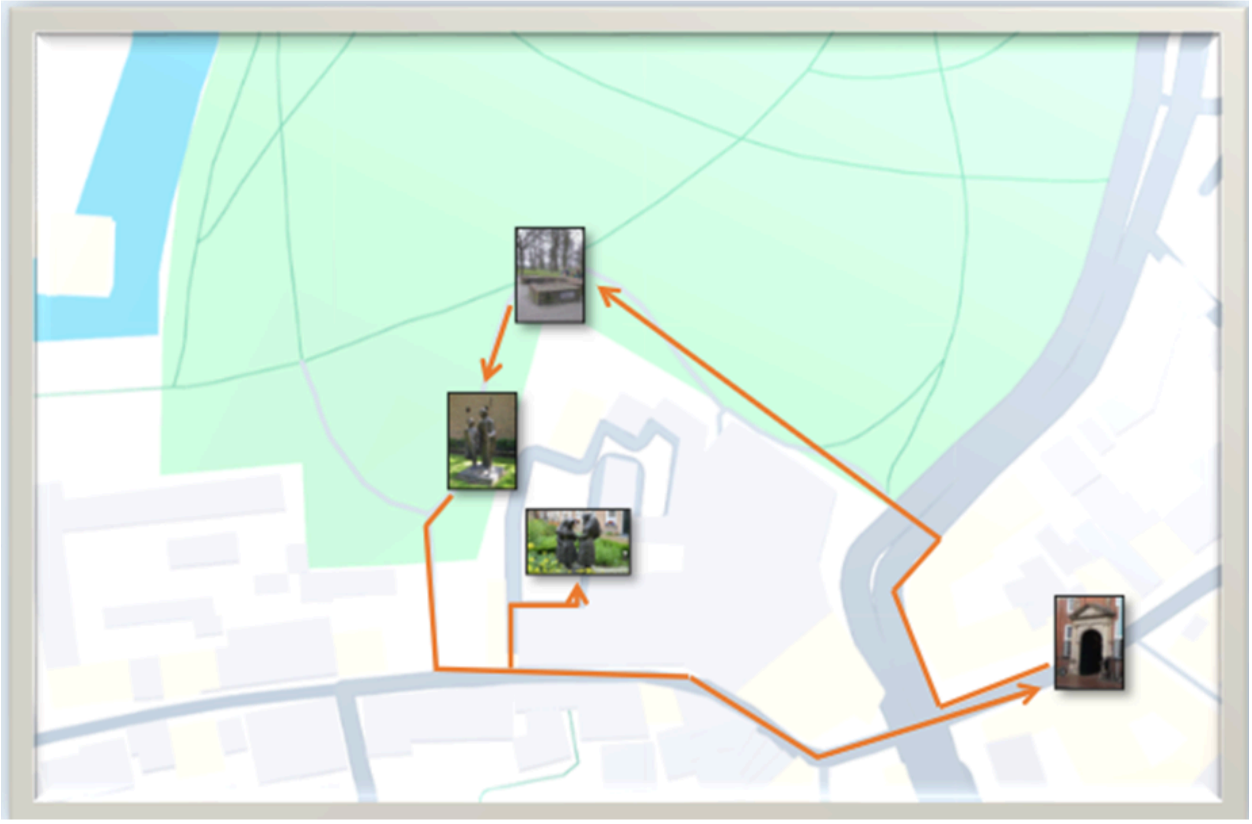

Figure 5 - Demo Route

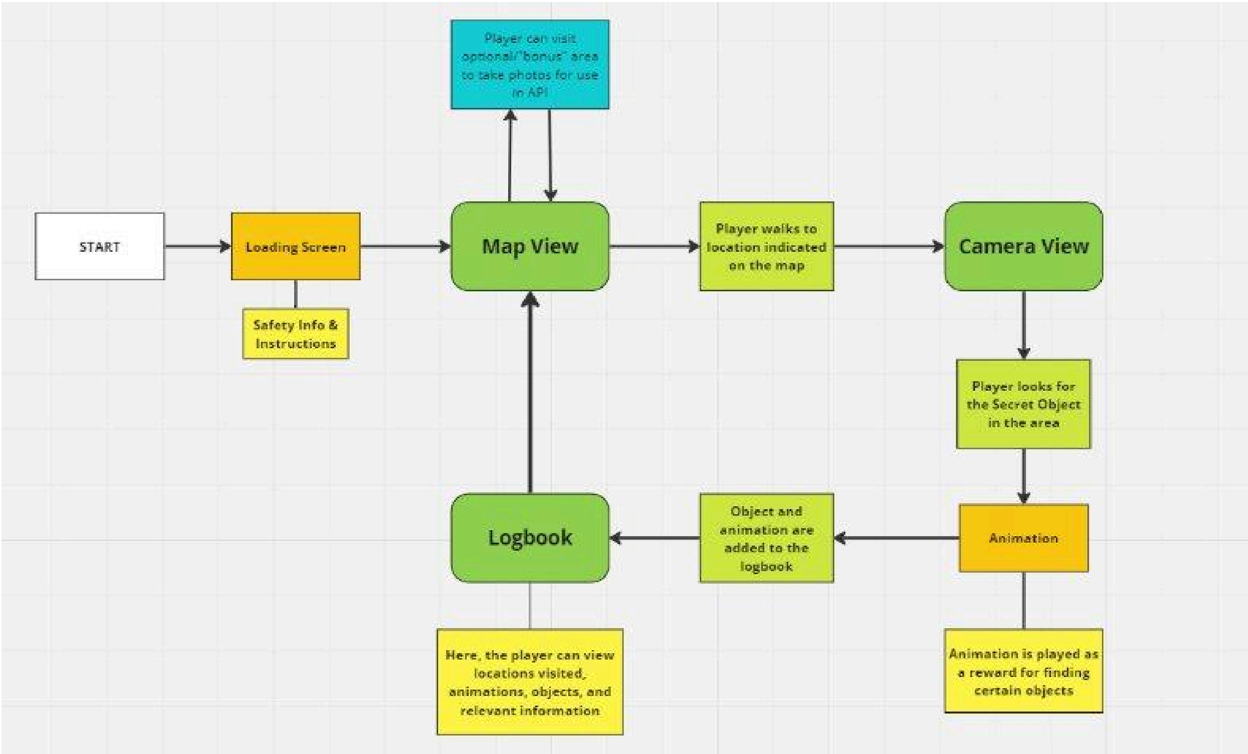

Figure 6 - Main Game Loop

Games

Media

Hotel

Facility

Built Environment

Logistics

Tourism

Leisure & Events

Games

Leisure & Events

Tourism

Media

Data Science & AI

Hotel

Logistics

Built Environment

Facility

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