WPI

Albanian Spaç Prison

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Abstract:

Cultural Heritage without Borders - Albania is a non-governmental organization focused on creating a civic space for deliberation about cultural heritage. Within Albania, this specifically includes a reckoning with totalitarian rule and its consequences. In a team of two, the group designed and implemented a series of features into an existing model of an Albanian Spaç Prison digital reconstruction project. The project's goal is to draw attention to the Spaç Prison as a historical site since there is a disconnect between older generations recounting the historical traumas experienced and newer generations understanding the significance of the site and history. The implemented features were aimed to make the model more aesthetically pleasing and more compact, as well as to improve the user interface (UI). Survey results showed that our team had made both stylistic improvements throughout the model and site, as well as faster loading times in displaying the model.

Acknowledgements

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- Professors Joshua Cuneo, Ralph Sutter, and Robert Hersh for their guidance and support as our advisers
- Mirian Bllaci and Cultural Heritage Without Borders - Albania (CHwB) for giving us the opportunity to work on this project
- The previous IQP students who began work on this project: Elizabeth Kirschner, Leo Gross, Michael Clements, and Zetta Rajaniemi
- WPI students and CHwB members for their participation in our online survey

Authorship

This team was composed of two group members: Anagha Late and Rory Sullivan. Anagha is a Computer Science major from Tewksbury, Massachusetts, with a focus in HCI and software development. Rory Sullivan is a Computer Science and Interactive Media & Game Development double major from Hopkinton, Massachusetts, focused on front end development. The project was completed within 7 weeks (one term) at Worcester Polytechnic Institute, differing slightly from most MQPs, which typically take place over the course of 3 terms.

This project was performed by splitting up the report/writing section and the technical deliverable section between the two members of the MQP proportionally. However, the focuses of both members were slightly different. This can be contributed to the fact that Rory Sullivan was completing both the Interactive Media & Game Development and Computer Science requirements while Anagha Late was completing solely the Computer Science requirement. Members wrote sections in the report based on their respective technical contributions. The chart below breaks down contributions of both the report and the technical deliverables.

Authorship Breakdown

Rory Sullivan = RS, Anagha Late = AL

Section	Main Writer	Main Editor
Abstract	RS	AL
1.0 Introduction	-	-
1.1 History and Background	AL	RS
1.2 Legacy of the Albanian Communism	AL	RS
1.3 Existing Work in Digital Reconstruction	RS	AL
1.4 Refining the Spaç Digital Model	RS	AL
2.0 Relevant Technologies	RS	AL
3.0 Design and Implementation	-	-
3.1 Making the Model Lighter	-	-
3.1.1 Compression	RS	AL
3.1.2 Server Side Loading	AL	RS
3.2 Making The Model More Aesthetically Pleasing	-	-
3.2.1 Fixing Clustered Labels	RS	AL
3.2.2 Terrain Effects	RS	AL
3.2.3 Axis of Rotation	RS	AL
3.2.4 Camera Movements	RS	AL
3.3 Rethinking the User Interface	-	-
3.3.1 Label Feedback	AL	RS
3.3.2 Visual Improvements	AL	RS
4.0 Survey Results and Findings	-	-
4.1 Conducting A Survey	AL	RS
4.2 Methodology and Analysis	RS	AL
5.0 Conclusions and Recommendations	ALL	ALL
5.1 Looking Forward	AL	RS
5.2 For Future Teams	AL	RS
5.3 Conclusion	AL	RS
6.0 References	ALL	ALL
Appendix	ALL	ALL

Table of Contents

1.0 Introduction:

1.1 History and Background

Throughout the four decades of his communist rule, dictator Enver Hoxha led Albania through splits with several allies, purging vast numbers of his own Party members and their families upon each occurrence.[1] While incorporating a mixture of Albanian nationalism, he implemented several similar ideologies and methods of repression that Stalin carried out in his two decades of rule.

In the detailed accounts in *Life is War*, several interviewees narrate examples of oppression, such as declaring those who strayed as 'enemies of the people' and further torturing their families by relocating them to distant villages in order to isolate them.[1] In hopes of maintaining the nation as a paranoid and isolated state, Hoxha declared Albania as an Atheist state in 1967, adopting a version of Mao Zedong's Cultural Revolution and declaring war against all religion and superstition.[1] This was a method used in order to resist the regime and undermine the power of the Catholic church in the North and the Orthodox church in the South.

The regime operated in a manner in which behavior was closely monitored, instilling both paranoia and fear. A 1984 report by Amnesty International entitled *Albania: Political Imprisonment and the Law,* further provides details about the system of repression in place, highlighting the concerns of the times of the regime. These concerns ranged from human rights violations to a breach of international standards set down in the United Nations Standard Minimum Rules for the Treatment of Prisoners.[2]

This was mainly due to the establishment of the Sigurimi, or the Albanian Directorate of State Security. Directing their activities more toward ideological and political oppositions rather than crimes against property or person, the Sigurimi was key in the creation of the surveillance state.[2]

However, in order to enjoy their elite statuses and privileges, members of the Sigurimi had to maintain their loyalty by continuously waging a war to divide and conquer Albanian families and communities.[1] They did so by further dividing their troops into groups that would then monitor a specific sub-section of Hoxha's oppressive rule, some of which included monitoring censorship, public records, and counterespionage.

It is important to note that the Sigurimi troops actually consisted of thousands of Albanian citizens who acted as informers for the communist regime.[2] They were either paid a pittance or, more often, blackmailed into helping keep tabs on their fellow citizens.[3] A number of former political prisoners have told Amnesty International that they were convicted on the basis of the testimony of informers or plainclothes Sigurimi members, some of whom had deliberately provoked them to criticize the authorities.[3] It was by enforcing the ideological principles present that the regime was able to force their citizens to oblige.

Hoxha's repressive regime furthered after 1978, when the country of Albania split ties with China due to differences that arose from conflicting interpretations of communist ideologies. It was during this time that the dictator sought after and purged notable groups of individuals, some of which included cultural imperialists, businessmen, politicians, and influential intellectuals. Identifying these individuals as a threat to Albanian nationalism, he established a system of labor camps, detention camps, and prisons in order to coerce the population and stifle any descent.[1]

This led to the establishment of the Spaç Prison - a notorious labor camp containing some of the most prominent Albanian intellectuals of the twentieth century. Due to its large size, Spaç was also able to imprison ordinary men who convicted crimes on a relatively lower profile.[1] Located in a remote and mountainous area in the center of the country, the isolated site required no need for a secure perimeter. As stated in the Amnesty International report, the conditions in the forced labor camp of Spaç did not conform to the international standards set down by the United Nations, and thus those who experienced such times and are alive today recount their stories of hunger, isolation, and oppression.[2] Many of the men that were sent to the Spaç Prison were subject to humiliation, violence, and deadly living conditions.[2]

The Spaç Prison became the site of a famed prisoner's revolt in May 1973 - one of the very first movements to resist the communist regime.[1] This signified the early beginnings of the resistance and thus the historical importance of the site in regards to the communist era.

From 1944 to 1985, the number of people that were executed, imprisoned, or sent to internment camps and prisons such as Spaç, exceeded over 1/30th of the Albanian population at the time - with about 103,670 individuals sentenced on politically motivated convictions and around 65,000 sent to concentration camps. Of the people that were executed, around 6,000 were

not allowed to a fair trial, and the remains of more than 5,000 victims still have not been found after they were buried in secret unmarked mass graves throughout Albania.[4]

1.2 Legacy of the Albanian Communism

Those who endured the time of the Albanian communist regime recount times of trauma and scarred memories, making it difficult to reflect upon their experiences.[5] Such experiences are similar to the stories told by Saimir Maloku, an Albanian engineer who was jailed for nine years in 1976 after the Sigurimi installed secret cameras and listening devices in his home without his knowledge. In efforts to broaden his paralyzed father's television viewing beyond the usual few Albanian state broadcasts, the engineer built a device that would allow him to view the channels seen in Italy, giving his household a peek into life outside of the communist regime. Sensing his efforts as a threat to the nation, the Sigurimi planted listening devices to gather criminal evidence against him, later convicting him of hostile "agitation and propaganda". Jailed without a trial, it was only upon visiting Tirana's Museum of Surveillance that he further learned about and saw for himself the different types of spyware that were installed to monitor those during the communist era. The museum is situated in the former Sigurimi headquarters, and Albanians today can now visit and learn about some of the spyware devices and tools used by the dictator. With the opening of the museum, Albanian citizens and tourists are able to understand the extent to which the surveillance state operated.[5]

Thus, due to the fact that there are a limited number of sites in the country that exist as a place of memory for the former prisoners of Spaç, there is a dire need to advance this knowledge to raise awareness of their history.[6]

In Albania today, several struggle with recounting the stories that make up their difficult history. Marianne Hirsch, a professor at Columbia University who has published widely on the transmission of memories of trauma across generations, uses the term 'postmemory'.[7] 'Postmemory' describes the relationship that the subsequent generations have in relation to the personal, collective, and cultural trauma of those before - more specifically, how those in succeeding generations only recall such experiences through stories, images, and the behaviors of those who grew up in earlier times.[7] The act of memory transmission from the earlier generation to those later may, however, suffer a disconnect at times, especially when the

memories in question are overwhelming and difficult to discuss. Professor Lori E. Amy, an independent scholar writing about Albanian history and cultural trauma, argues that normally literature, art, schools, and social spaces communicate experience across generations, but recent history containing generational trauma has broken these lines of transmission.[8] Furthermore, she believes that the cultural violence of Albanian communism has repressed and manipulated these social institutions, resulting in subsequent generations inheriting a fragmented and distorted view of the past.

In hopes of spreading awareness and knowledge about Albanian history, organizations such as the Cultural Heritage without Borders - Albania (CHwB) and the Albanian Ministry of Culture have declared it a priority to continue preservation efforts for historical and monumental sites such as the Spaç Prison. However, due to conditions such as vandalization and the weather, the site today lies in a state of deterioration where its future remains uncertain. Several buildings and structural components have been lost due to natural decay. In efforts to preserve the site, CHwB performed several structural interventions in 2017 to prevent the collapse of the remaining three buildings. Some of these measures also included emergency roof repairs and site clearances.[6]

For many, the remains of the Spaç Prison represent the damaged lines of memory transmission in Albania. In 2014, our sponsor, CHwB, initiated the project - *Sharing Stories, Shaping the Future: Dialogues for Spaç* with the goal of turning a place of ruin into one of reflection. The project intends to honor the memory of all those who suffered under the harsh conditions of Spaç and to provide all visitors with a civic education in order to help them understand how oppression arises in society and impels them to take positive action.[9]

In hopes of repairing these lines of transmission and achieving these goals, CHwB has developed a web application containing a digital model to help users learn more about the Spaç Prison. Serving as an interactive tour, the application would educate those of all ages about the experiences of Spaç prisoners, allowing them to further understand the times of the communist regime.

1.3 Existing Work in Digital Reconstruction

Digital Reconstructions are digitized rebuildings of structures. They can serve as a form of preservation for historical sites and objects of all kinds, whether that site has disappeared, is deteriorating, or is still intact. They serve as a useful tool for documentation, exploration, and educational purposes.[10] The reasoning behind this is that they have the ability to convey concrete visualizations, have continued preservation of the original site, and offer convenience.[11] The digital reconstruction of the Anne Frank house, depicted in figure 1, serves as a perfect example on how this form of media can be a unique tool for exploration, education, and documentation. Thanks to modern technology, virtual reconstructions are able to reach large audiences, and can be made with limited tools and time.

Figure 1: *Depictions of the Anne Frank House virtual tour.*[20]

Digital reconstructions of historical sites are becoming increasingly popular, especially as more and more technological tools and techniques become available. A crucial aspect to creating a historical site's virtual reconstruction is the consideration of which tools are available to aid in the process. Tools such as three-dimensional object modeling, terrain modeling, 360 degree images, and satellite images are all important instruments to consider. Each tool previously mentioned has both advantages and disadvantages when compared to the others.

Design and presentation techniques in this section are cited from virtual reconstructions of the Auschwitz concentration camp as well as that of a Syrian military torture prison

(Saydnaya prison). The Auschwitz model (http://panorama.auschwitz.org) consisted of satellite imagery and 360-degree panoramas. The reconstruction enables viewers and users to explore many important outdoor areas; however, it is more limited in exploration of indoor areas. Related text and background information is supplied to the user along with visuals which vary depending on what section the user is currently exploring. Furthermore, the site allows for translation of this text between English and Polish.

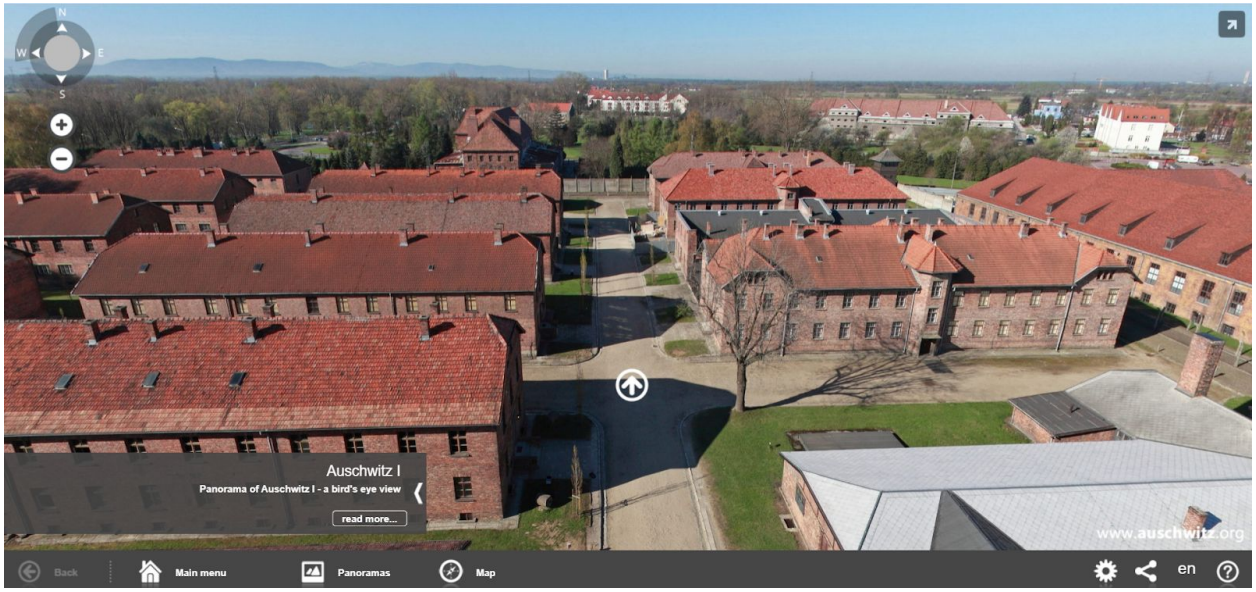

Figure 2: *UI, design, and 360 panoramas of the Auschwitz model* [12]

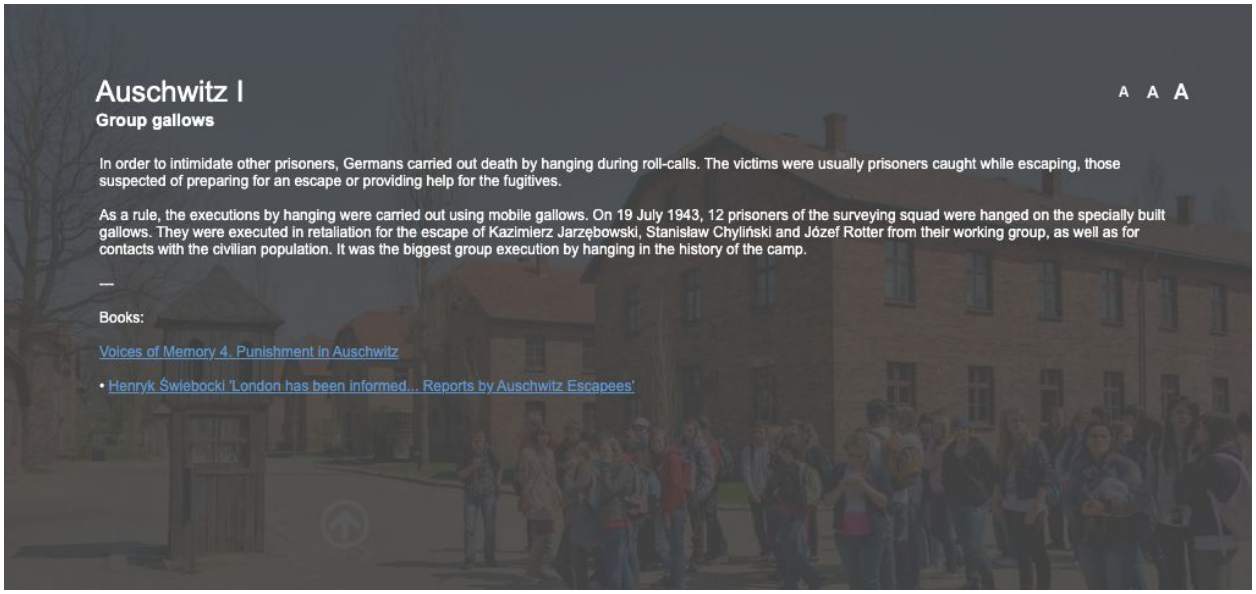

Figure 3: *The Auschwitz model displays informative text relating to the area of current exploration within the model.*[12]

The Syrian military torture prison (https://saydnaya.amnesty.org/) is far more stylized when compared to the Auschwitz concentration camp since it has added a grayscale effect to the terrain in order to make it better blend with the grey 3D building models. This virtual reconstruction took the different approach of using Computer Aided Design (CAD) models to represent the prison, as opposed to the Auschwitz concentration camp model which used satellite and 360-degree imagery. Instead of clicking in a direction for your virtual camera to move towards, the torture prison gave a bird's-eye view of the model with several points attached which allowed for a zoomed-in view. The site had very similar elements to the Auschwitz reconstruction site, such as useful text, stories, and information on the location. Something interesting about this model was that it included sound and background noise. These sounds were not recorded but instead were generated with the aid of technology using a technique known as acoustic modeling, which essentially generates noise fragments resembling possible words from a base sound.

Figure 4: *UI, design, and 360 panoramas of the Syrian military torture prison model* [13]

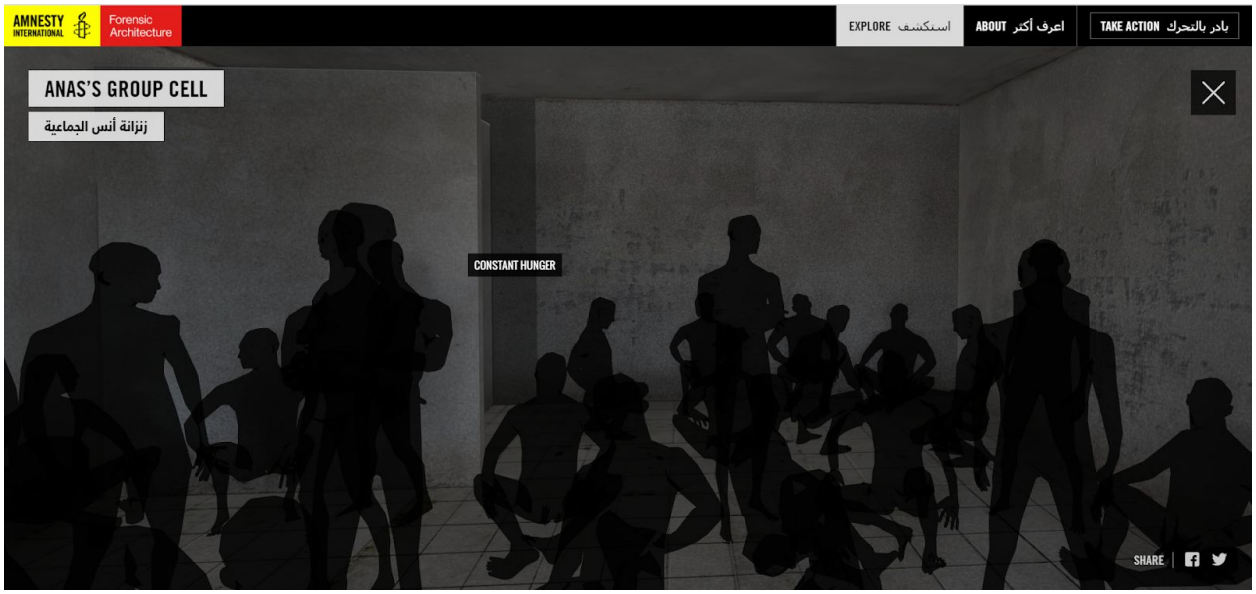

Figure 5: *3D model of a cell in the Syrian military torture prison as opposed to 360-degree imagery* [13]

1.4 Refining the Spaç Digital Model

In the fall of 2019, Worcester Polytechnic Institute (WPI) students began work on the Spaç prison digital reconstruction model. The project accomplished a significant amount of work on the digital model (https://spac-prison.glitch.me/), interviewed former prisoners, recorded compelling stories, and completed user testing on the site. The site gave a rough untextured mapping of the terrain around the prison, along with a CAD model of the prison. Similar to the Syrian military torture prison, the student team used a bird's-eye view model of the prison with several points to click on and zoom into. However, upon zooming in, the group decided to use 360-degree images, similar to the Auschwitz concentration camp model. The site offered useful text applicable to wherever the user was allowed to explore.

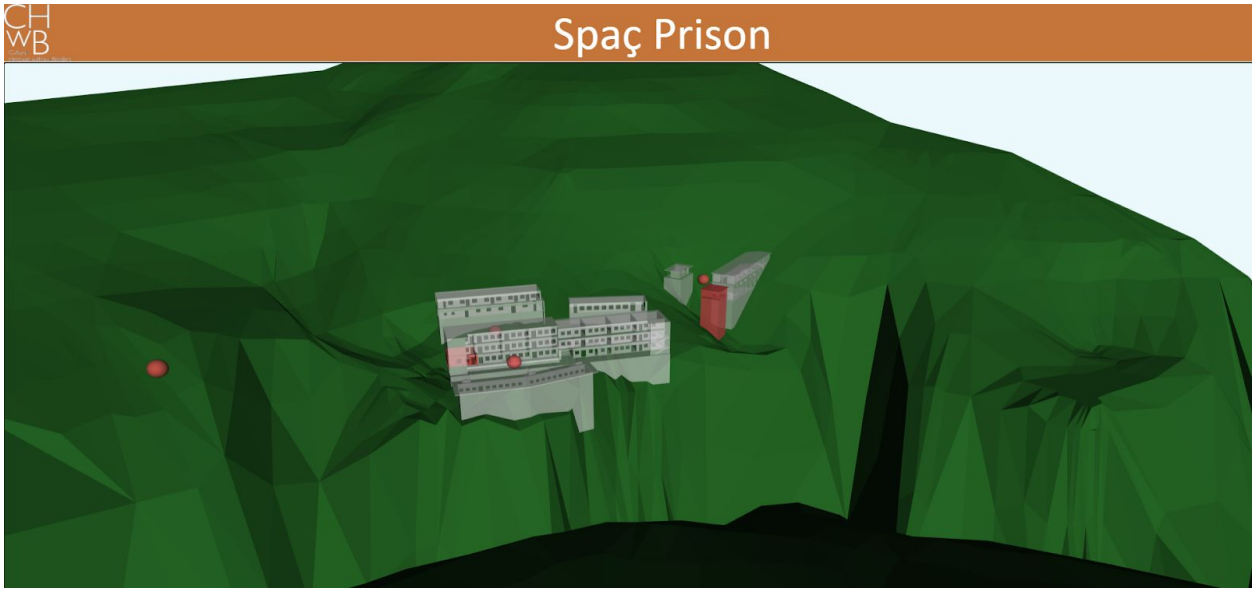

Figure 6: *Bird's Eye View of Spaç Prison from the WPI IQP digital reconstruction model.*[14]

Figure 7: *A sample of a 'zoomed in' area of the Spaç Prison from the WPI IQP digital reconstruction model.*[14]

After the project was completed, the sponsor, CHwB, continued work on the virtual reconstruction of the Albanian Spaç Prison (www.spacprison.com). The organization began work

to redesign the site's user interface. As a result, the site's aesthetic more closely matches that of the Syrian military torture prison site. Some notable progress made by CHwB on the virtual reconstruction includes the following: the terrain was redone and textured to more closely match that of the real life prison, additional points were added to the model for users to explore, and labels were added to said points.

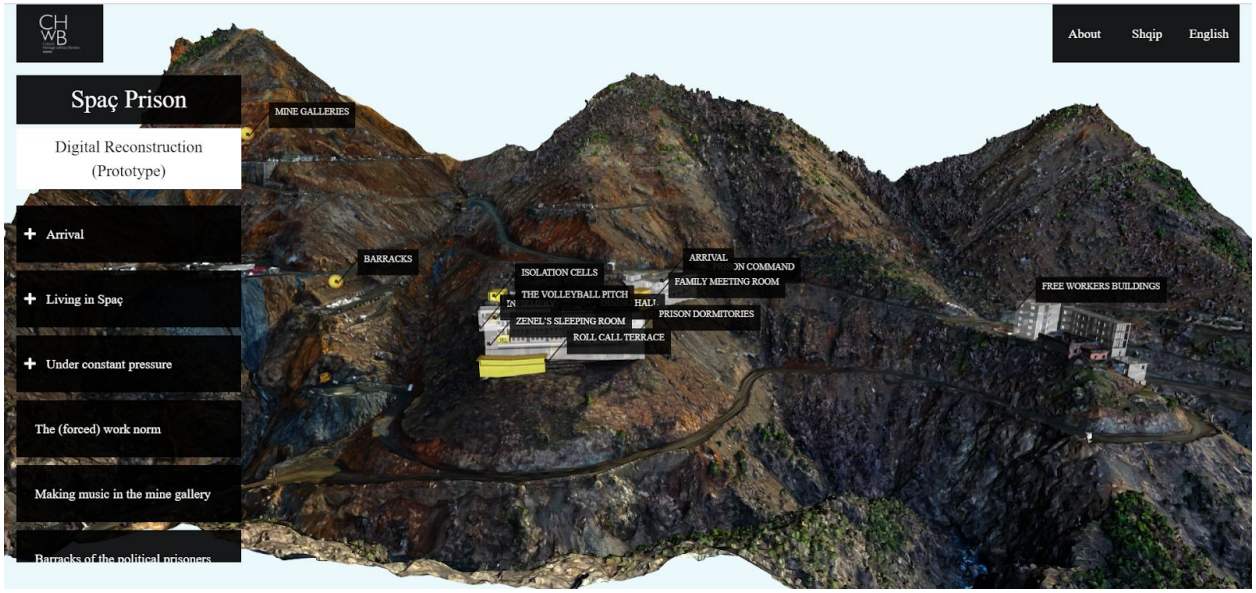

Figure 8: *Updated terrain, labels, and UI from the CHwB team.*[15]

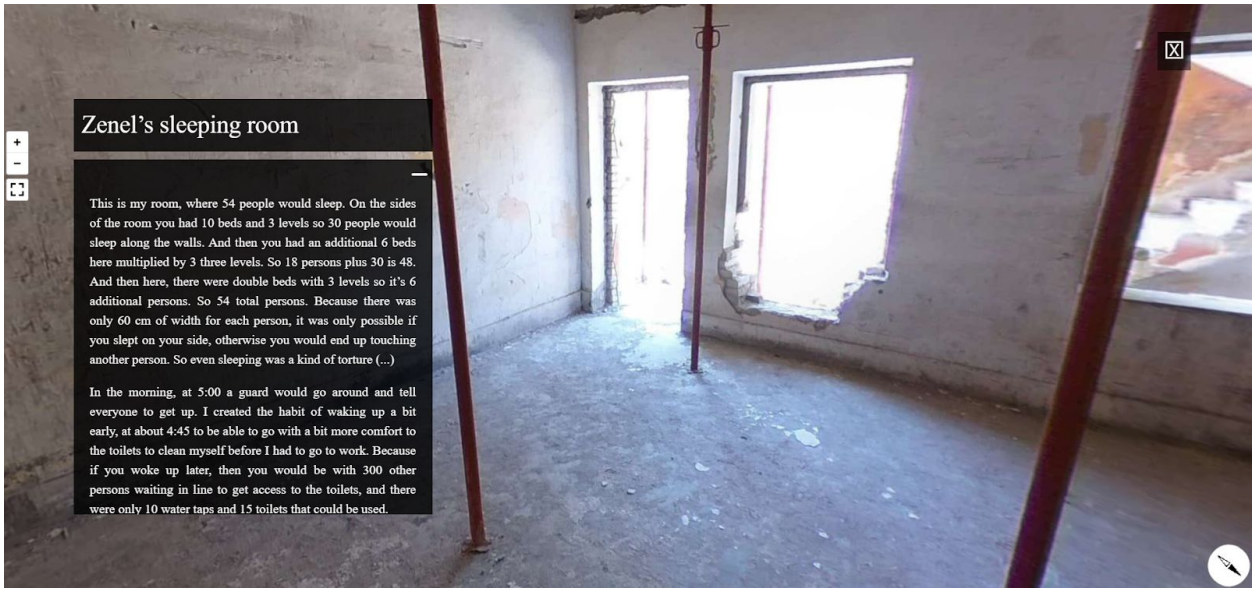

Figure 9: *Updated UI of a 'zoomed in' area of the Spaç Prison from the CHwB team.*[15]

Although much progress was made in the virtual reconstruction of the Albanian Spaç Prison by both WPI students and consultants hired by CHwB, plenty of work remained. With the aid of Mirian Bllaci, the program manager of CHwB, several tasks were identified and prioritized in relation to continuing the work of virtual reconstruction. Some tasks included implementing labels for the CAD models and a 'language' feature which enables the user to switch between English and Albanian, similar to that seen on the Auschwitz concentration camp site. CHwB would like the virtual reconstruction model to be less large in overall file size and less resource intensive so that it could be run on older, less powerful computers which are prevalent in Albania.

2.0 Relevant Technologies

There were many technologies used that make up the entirety of the digital reconstruction for the Albanian Spaç Prison. Overall, the programming for the site was done in Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), and Javascript (JS). Throughout the project, both team members used the Interactive Development Program (IDE) of Webstorm to make program edits. A major runtime environment the program relies on is Node.js, an open-source, backend, run-time environment that allows JavaScript code to execute outside a web-based browser. The editing and testing process was made easier throughout development by using Gulp.js, which is a streaming build system in front-end web development allowing for edits to synchronize with the browser. Three.js was the library used in the digital reconstruction to create and display animated 3D computer graphics in a web browser. This tool was vital to the texturing and rendering of the terrain and models as well as camera and lighting implementations. The Version Control System (VCS) used throughout development was Git, which acted as a code sharing and publishing service. In order to host the site for demonstration purposes, Heroku, a cloud as a service platform, was used.

3.0 Design and Implementation

3.1 Optimizing the Model

3.1.1 Compression

The load time for the model, even on a robust machine, takes around three seconds to load. This load time occurs every time the main model page is brought up, which is something expected to happen frequently when exploring the prison. The original terrain file size was 68.5 MB and contained 999,999 polygons. The texture of this terrain was 8192x8192 pixels, which is massive considering, according to Professor Sutter, most textures do not exceed 2048x2048 in web-based, real-time, interactive media. Both of these factors likely contributed to the slow load times.

In order to reduce the size of the texture, the application GIMP was used, which is a free and open-source graphics editor used for image manipulation and image editing. The program was successfully able to reduce the texture size from 8192x8192 pixels to 2048x2048 pixels, which is exactly 1/16th the file size. While the program was able to reduce the texture size drastically within it's UV map, which is "the flat representation of the surface of a 3D model used to easily wrap textures" where 'U' and 'V' denote the axes on the 2D texture.[16], it was also able to maintain much detail to a point where hardly any noticeable differences can be seen, as displayed in figures 10 and 11.

Despite the overall reduction in size, the texture utilization in terms of its UV layout could be further optimized. The initial way in which the terrain was unwrapped, or the way in which its 3D geometry was flattened into a 2D space, was very inefficient. This was due to the fact that it used a form of UV tile mapping. In other words, rather than having one set of UVs for the entire terrain, the map was broken up into smaller fragments of UV space. This is considered an inefficient technique because the mesh essentially had UV seams running across the entire surface. This not only caused visual artifacts, but also added to the object's file size. Another reason this is considered an inefficient technique is because the color texture itself was illegible for editing purposes. The reason it could not efficiently be edited was because it appeared as a mess of scrambled information in an image editor (as seen in figures 10 and 11). As a result, the

entire map was instead given a single, proper UV space. This ensured that only the UV seam ran across the outer border of the geometry and not within the terrain. The byproduct was a single flat texture of the terrain that can be read as such, as seen in figure 12. This allowed for the efficient painting of a transparency alpha texture (further referenced in section 3.2.2) since the actual shape of the model could be made out, unlike the original textures depicted in figure 10.

Additionally, using the program 3ds Max, a professional 3D computer graphics program, the group was able to significantly reduce the number of polygons in the terrain model itself. The terrain model was reduced from 999,999 polygons to 199,952 polygons, or 20% of the original count. This was done using the tool proOptimizer found in the modifier list of 3Ds Max. Once again, even with such a significant compression of the model, little to no reduction in quality of the model could be seen, as shown in figures 13 and 14. Once implemented into the virtual reconstruction, these optimizations were able to visibly reduce the load time of the model as explained later in the results section. In other words, the load time was reduced by 66.66%.

Figure 10: *The segment of the terrain's original texture containing 8192x8192 pixels.*

Figure 11: *The segment of the terrain's compressed texture when reduced to 2048x2048 pixels*

The original tiled texture:

The updated texture:

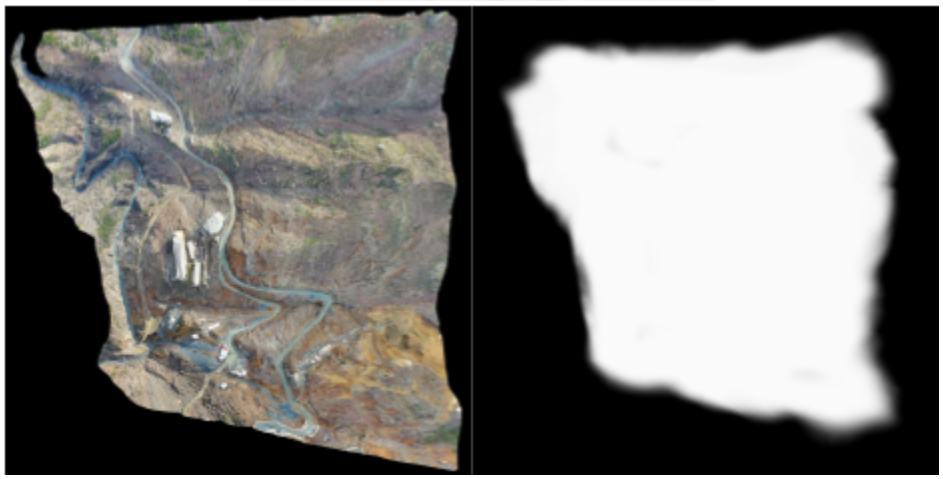

Figure 12: *The tiled terrain texture compared to the updated flat color and alpha map of the terrain.*

Figure 13: *A portion of the terrain model with 999,999 polygons.*

Figure 14: *A portion of the terrain model after being compressed to 20% the original vertex amount.*

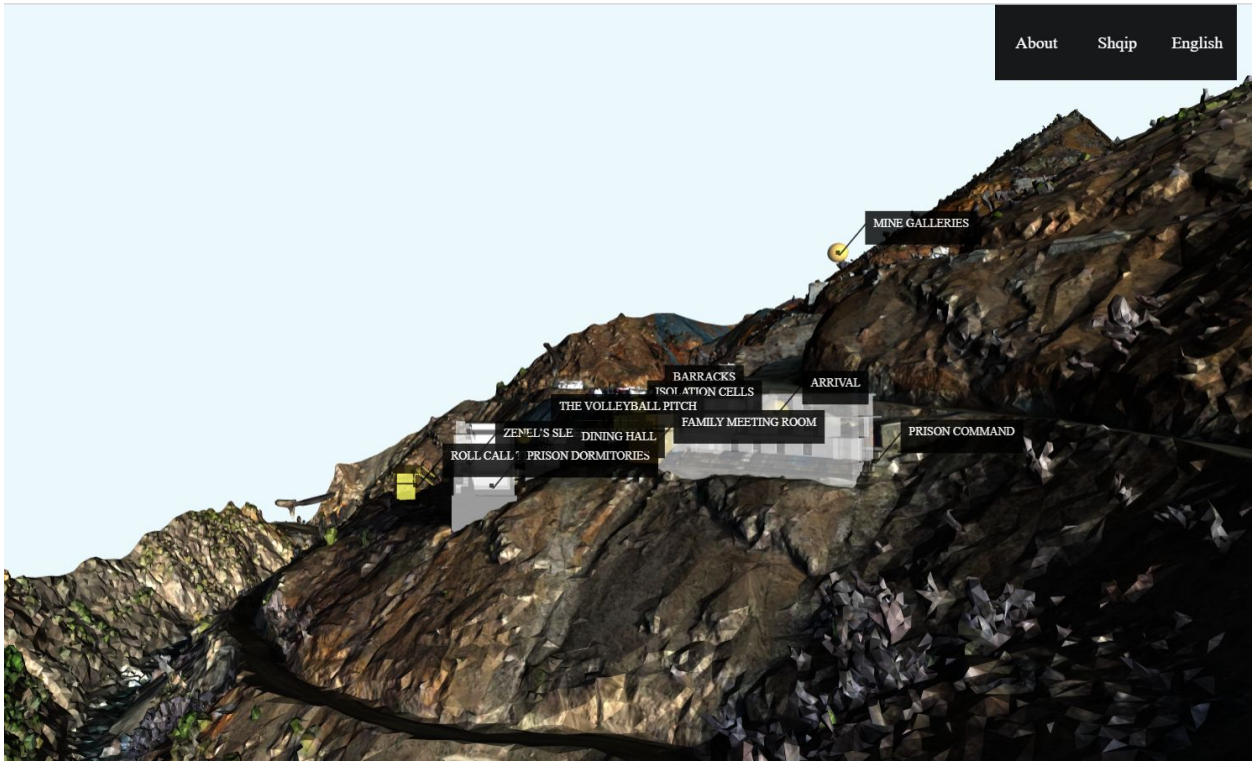

Figure 15: *The original model and texture combined and implemented into the site.*

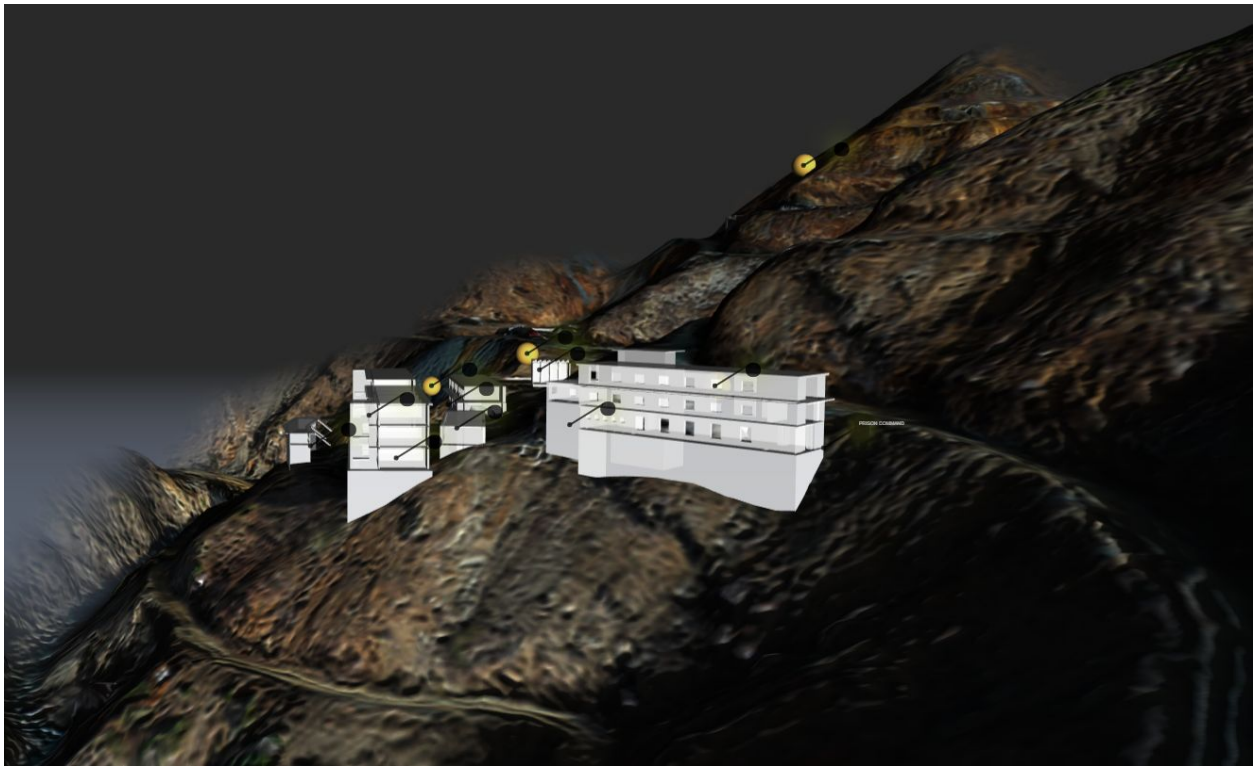

Figure 16: *The updated model and texture combined and implemented into the site.*

3.12 Server-Side Loading

Load times were of significant concern since the application had a wait time every time the 3D model was called, interfering with the user's overall experience. This is an important concern since after a clickable label on the model is selected, the site navigates to its respective target, navigating away from the model page and to the desired page in which the label is further elaborated on. However, upon exiting the sub-page, the site navigates to its previous target - the main page in which the model is located, which causes the application to load the model once more. Thus, when a user navigates between subpages, the application loads and runs relatively slower. This issue may be attributed to the lack of dynamic loading within the application - a mechanism in which the main module is loaded first and remains locally stored. Other relatively smaller modules, such as sub web-pages, are only loaded as they are accessed by the user.

Thus, our team's strategy was to load all webpages and visual elements upon first launching the application into the server. Although the user would still encounter a long initial load time in which the application would be unresponsive, this method would prevent the longer and redundant load times that would be encountered when using the application and switching between pages. Our team suggested storing the objects in the Node.js server. By caching the model on the client side upon the first launching of the application, the program can then retrieve the objects at a later time, contrary to loading the objects upon every occurrence of the user accessing them.

Along similar lines, our team suggested modifying how often the web application cache gets cleared. The Cache, or the software component that stores data, is used in applications so that future requests for that specific data can be served faster since it is stored locally. Thus, the components that are previously loaded and 'remembered' are presented on the screen at a relatively faster rate. With this said, our team suggested adopting object caching techniques, a method in which only certain heavy objects, such as the digital prototype of the Spaç Prison itself, are stored. By doing so, the user will recognize faster loading times when switching from the sub-pages to the main model page.

3.2 Application Aesthetics

3.2.1 Fixing Clustered Labels

The first step of design was to identify key areas of improvement that could be addressed when looking at the current model. After talking with Mirian Bllaci, several features were discussed and pinpointed as such. The first major design flaw in the current model was related to the overlapping of building labels. When certain angles and certain extents of magnification were applied to the model, some tags were pushed to the background, making it impossible to read the text essential to the design, as seen in figure 17. Several solutions were discussed with our sponsor such as a toggle for the tags, hover capabilities, and automatic position re-adjustments to avoid tags overlapping.

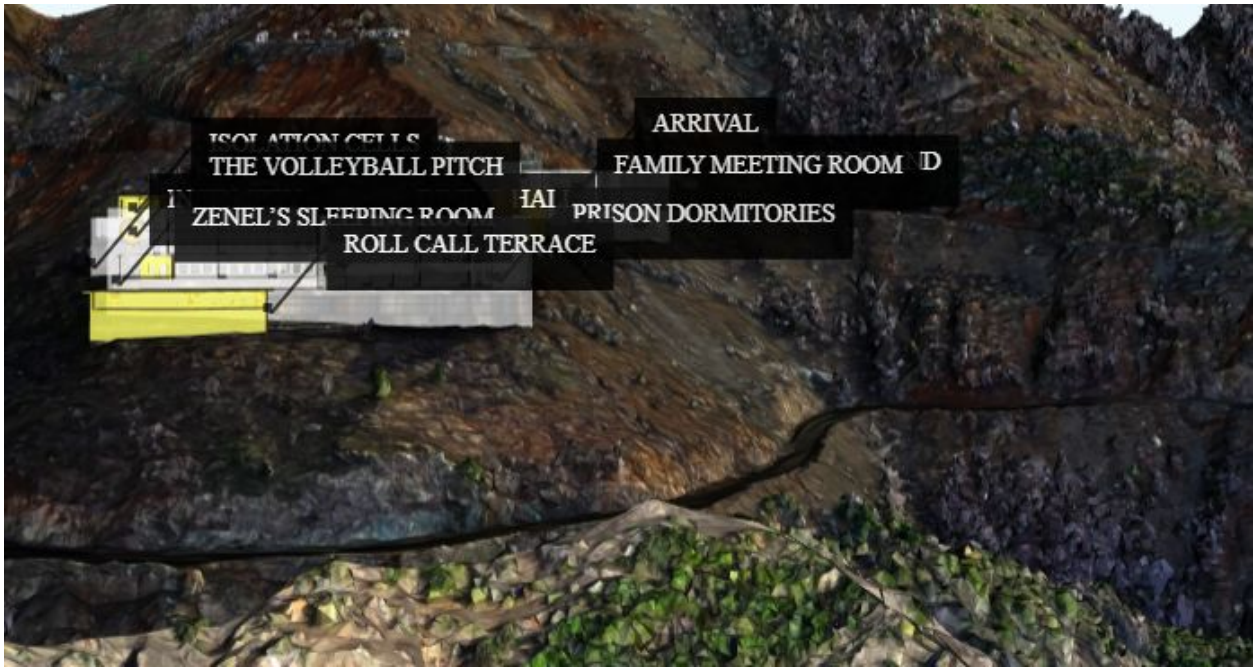

Figure 17: *Clustered and Overlapping model tags on the current prison model.*

When addressing the issue of clustered labels, the solution Mirian Bllaci favored most was the approach of implementing hover capabilities to the tags. This approach involved initially removing text from labels and minimizing them to a small circle shape with a slight glow effect to prevent the labels from overlapping, as seen in figure 18. Upon hovering over a building, the building would be highlighted green and all labels attached to that building would then expand.

Then, each label's text would be added back into the tag. All labels not attached to the hovered-over building would remain minimized, once again ensuring that no labels overlapped, as shown in figure 19. A transition effect was additionally added to the maximizing and minimizing of label size and shape in order to make the change in appearance more elegant.

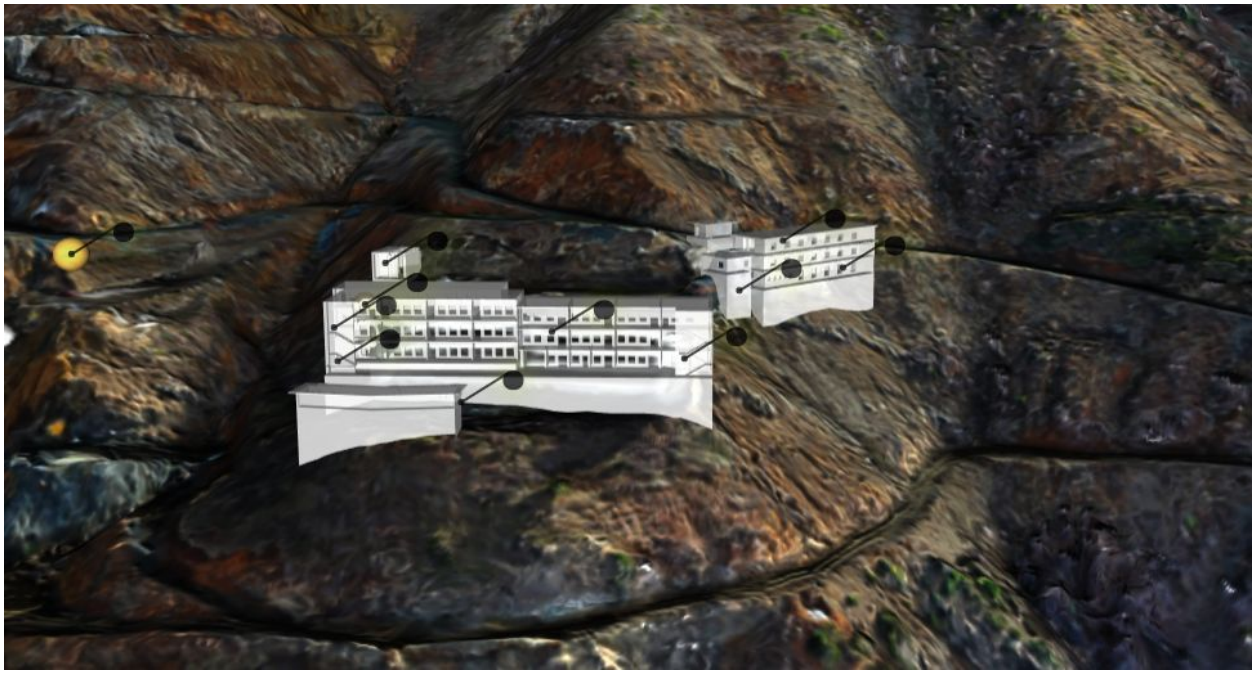

Figure 18: *Labels made into small circles with a slight yellow glow effect in an effort to reduce clustering.*

Figure 19: *A view displaying expanded tags and a highlighted building when said model is hovered over.*

3.2.2 Terrain Effects

When comparing the current Spaç Prison digital reconstruction to the Saydnaya Prison digital reconstruction, the most striking difference between the models lay within the terrains. The Saydnaya Prison's terrain has a color scheme that matches that of the building's models (figure 20). The terrain on the Spaç Digital Model is colored and finely textured whereas the models for the building are in grayscale (figure 21). Additionally, the terrain abruptly cut off into space since the terrain only consisted of a small patch of geometry with satellite data imagery, as shown in figure 22. In contrast, the Saydnaya Prison avoids this issue by never having the terrain's cut-off be made visible to the user. The cause of this cut-off terrain could be attributed to unrestricted camera movements and the terrain being mountainous as opposed to flat like the Saydnaya prison.

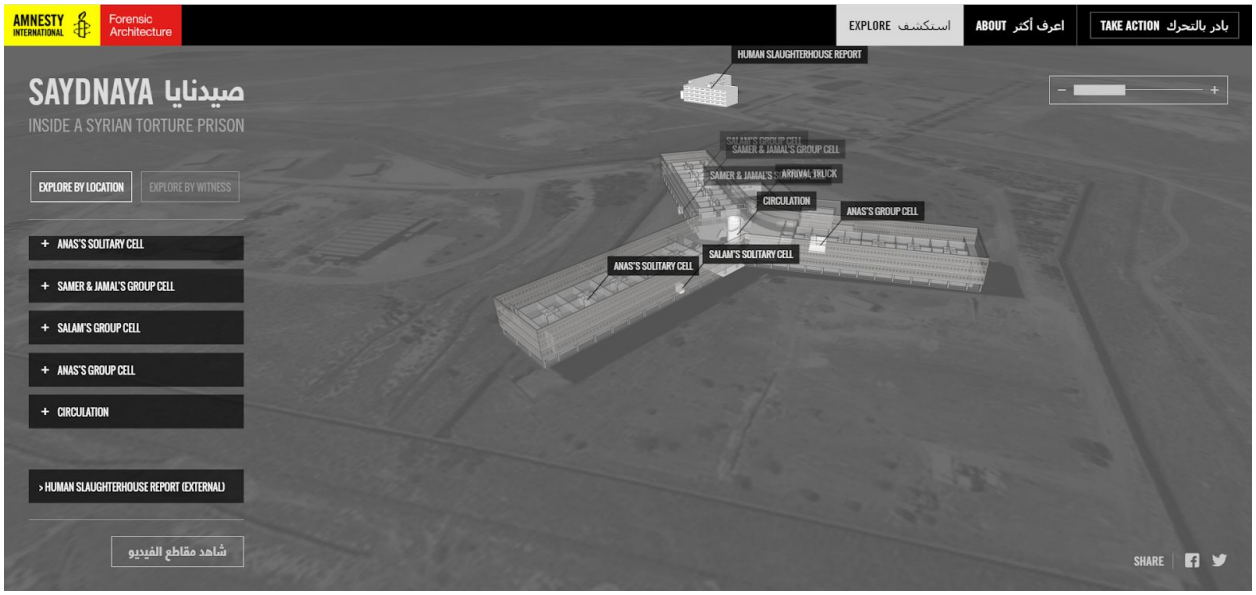

Figure 20: *Consistently gray color scheme throughout the Saydnaya Prison Model* [13]

Figure 21: *Terrain color clashing with model color.*

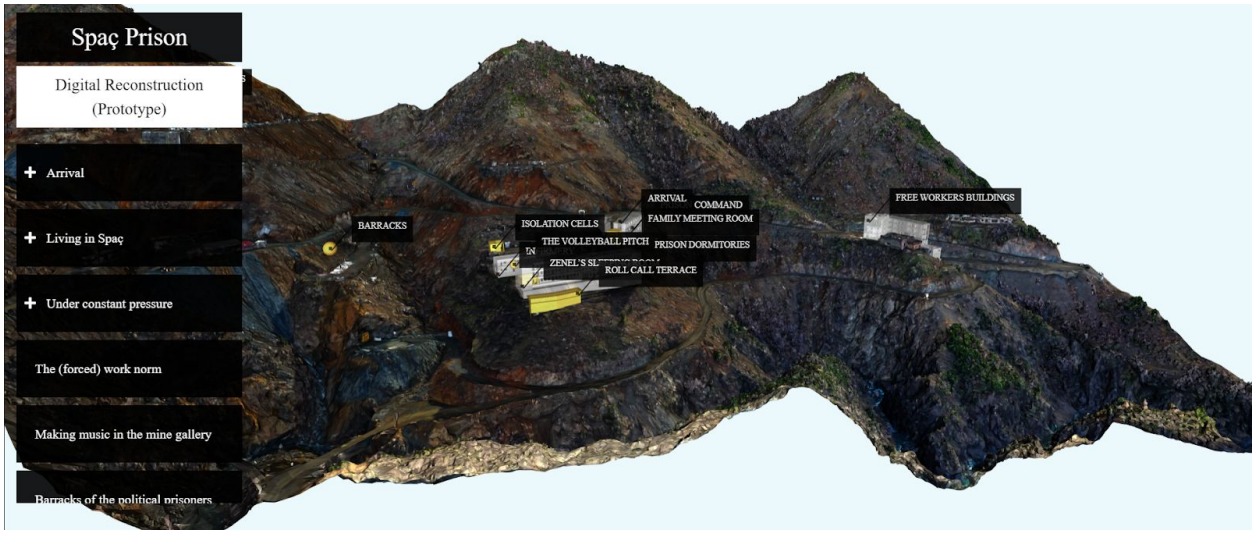

Figure 22: *Terrain abruptly ending on the current Spaç Prison digital reconstruction model.*

Several steps were taken in an effort to reduce the awkwardness of the terrain floating in space. In order to set the scene and continue the site's color scheme, our team opted to incorporate neutral tones rather than vibrant and distracting tones. Settling upon a gradient charcoal color for the background of the model, our prototype was able to convey a sense of mystery and seriousness. Furthermore, by creating less of a contrast between the terrain and the empty space in the environment, we were able to center the user's attention towards the terrain and model.[17]

Additionally, a floor plane was added to the model and made a lighter grayish color. The terrain was also given an alpha map which made the edges of the model fade into the background, as seen in figure 23. When combined, both of these features replicate an effect similar to an environmental fog. A final feature added to the terrain was a grayscale that becomes apparent when a label containing a target source is hovered over. This serves as a notification to the user that the tag they are hovering over is of importance, since everything else has become grayed out. This effect can be seen in figure 24.

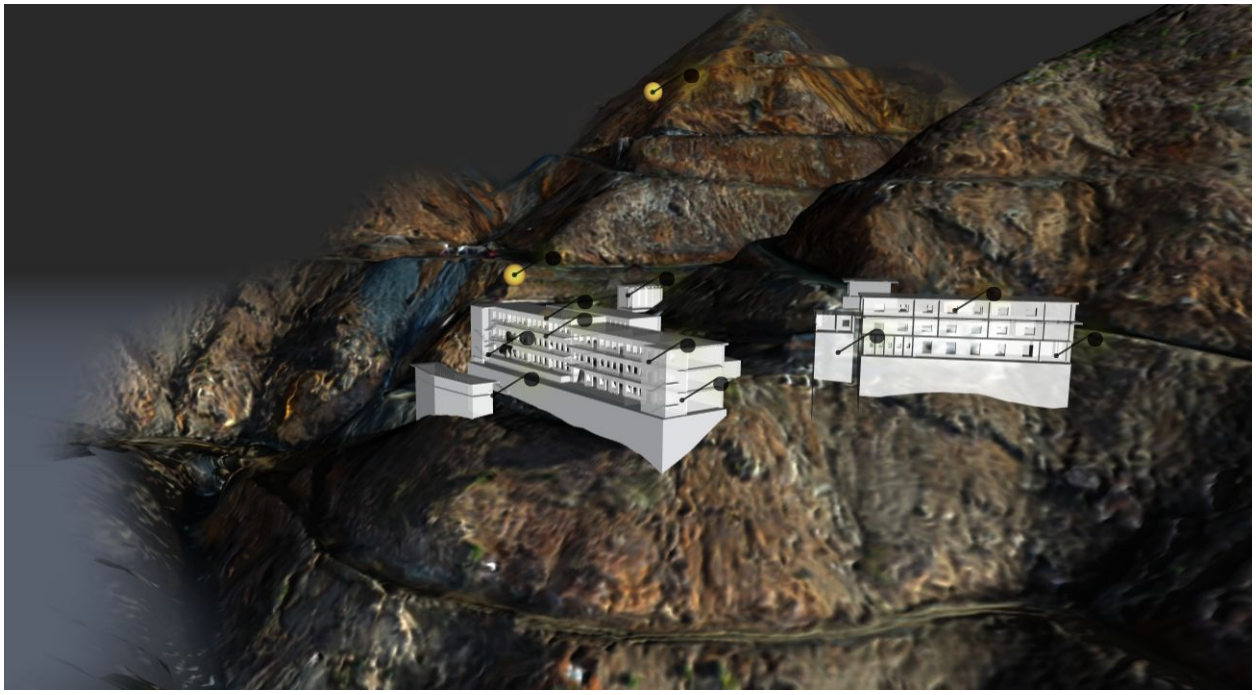

Figure 23: *A view displaying faded terrain edges, a darker background effect, and the additional 'fog' plane.*

Figure 24: *The terrain is grayed out upon hovering over a tag with a link attached to it.*

3.2.3 Axis of Rotation

When initially looking at the model, something the team identified as a flaw is the limitation of only being able to center on one focal point. There are several buildings and sites in the corners of the terrain that can not be properly viewed because of this, such as the Free Workers Building, Barracks, and Mine Galleries. Additionally, the center point of the model is initially set to a location which is off-center from the building that the view appears to be focused on. This creates confusion for the viewer upon attempting to zoom in on said building, as you are instead zoomed into an area between two models.

The group was able to determine that focal points should be limited as opposed to unlimited/determined by the user. However, there was still a need for increased numbers of focal points. As a result, the group determined that the focal points would be restricted to any building or model on the terrain. A common technique used in virtual models and maps is a double-click feature that re-centers the camera's focus point to the location clicked. This technique was applied to the Spaç Prison model so that once a user double clicks on any building or 3D object, the camera is refocused on these locations. This allowed for further exploration of models without the user feeling restricted.

3.2.4 Camera Movements

Upon detailed inspection of the current Spaç Prison digital reconstruction, the need of camera movement restrictions became apparent. In the current model, the camera was not limited in movement, allowing for camera angles that appeared glitched and models to appear as if they are colliding with one another, as seen in figure 25. These issues could be attributed to the ability for the camera to move behind the terrain. Additionally, the map could be zoomed out on such a large scale that the overall terrain and models would become nearly or completely invisible, as shown in figure 26.

Figure 25: *Terrain and object models that appear glitched once the camera movement is placed behind the terrain.*

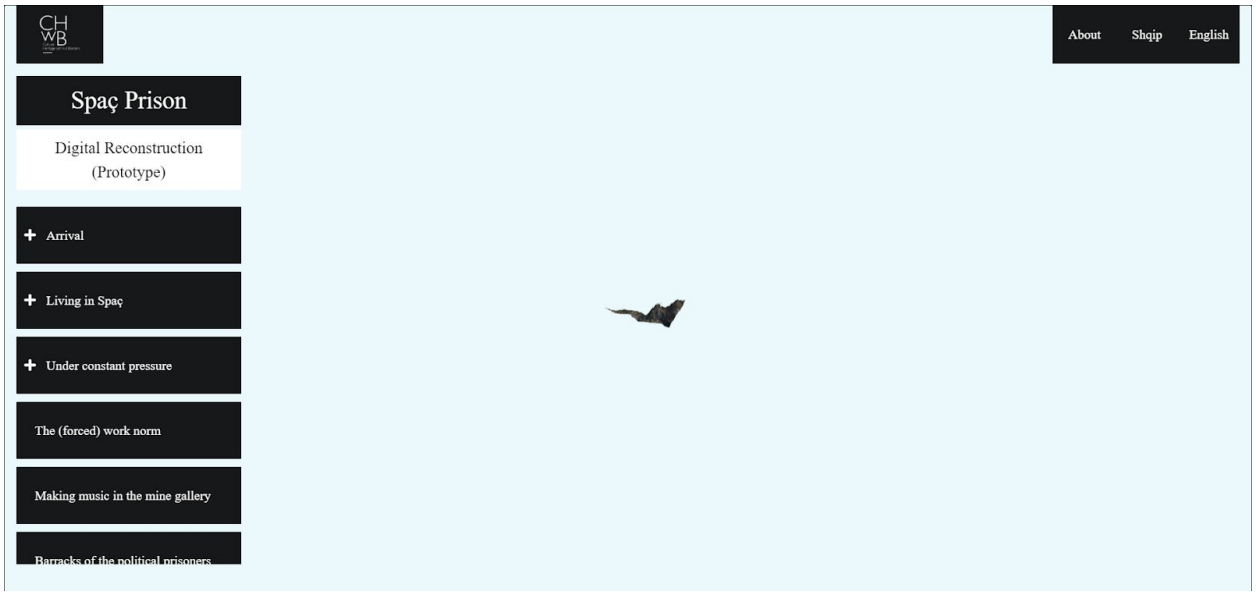

Figure 26: *A view of the model from an extremely zoomed out perspective.*

Three.js allows for several restrictions when it comes to camera movements. This made page zooming, vertical rotation, and horizontal rotation limitations quite easy to implement. However, upon adding the ability for users to double-click on a building and re-center the camera's focus point, the problem of static limitations became apparent. The original restrictions only worked for one focal point, and when this point changed, the restrictions needed to as well since every building was located in a different point on the terrain. As a result, the group implemented dynamic restrictions on camera movement depending on which building the camera is centered around. In other words, the limits for how far the camera should be able to move left or right were made dependent on which building the user is focused on.

3.3 Rethinking the User Interface

3.3.1 Label Feedback

Upon identifying key areas of improvements and encountering the design flaw enabling the overlapping and clustering of labels, it was also observed that certain labels did not have a target source. In other words, some labels would have hyperlinks attached to them leading to subpages while others did not, and there was stylistically no difference between these label types. With around 5-7 labels falsely leading the user to click on them, several solutions were discussed in order to bypass this design flaw. These solutions ranged from incorporating visual elements that would guide the user through the app to hiding the tags which were unable to redirect the user.

In order to prevent the user from mistakenly clicking on labels that possess no target source, the team decided to implement several subliminal stylistic choices in the CSS code in order to provide visual feedback. With the main goal of encouraging users to search for clickable elements rather than those without a target, several UI elements were altered. First, when hovering over a building, the corresponding labels that are attached to that building maximize and turn yellow. Contrary to the buildings themselves, upon hovering over the newly showcased labels, those that possess a target source and are able to navigate the user to a new subpage are now highlighted in a green color, while those with a null target source remain the original yellow color (figure 27). Furthermore, if an unclickable label is clicked, the user is prompted with an error message, as displayed in figure 28.

Figure 27: *Labels possessing a target source highlight green while those with null sources remain yellow*

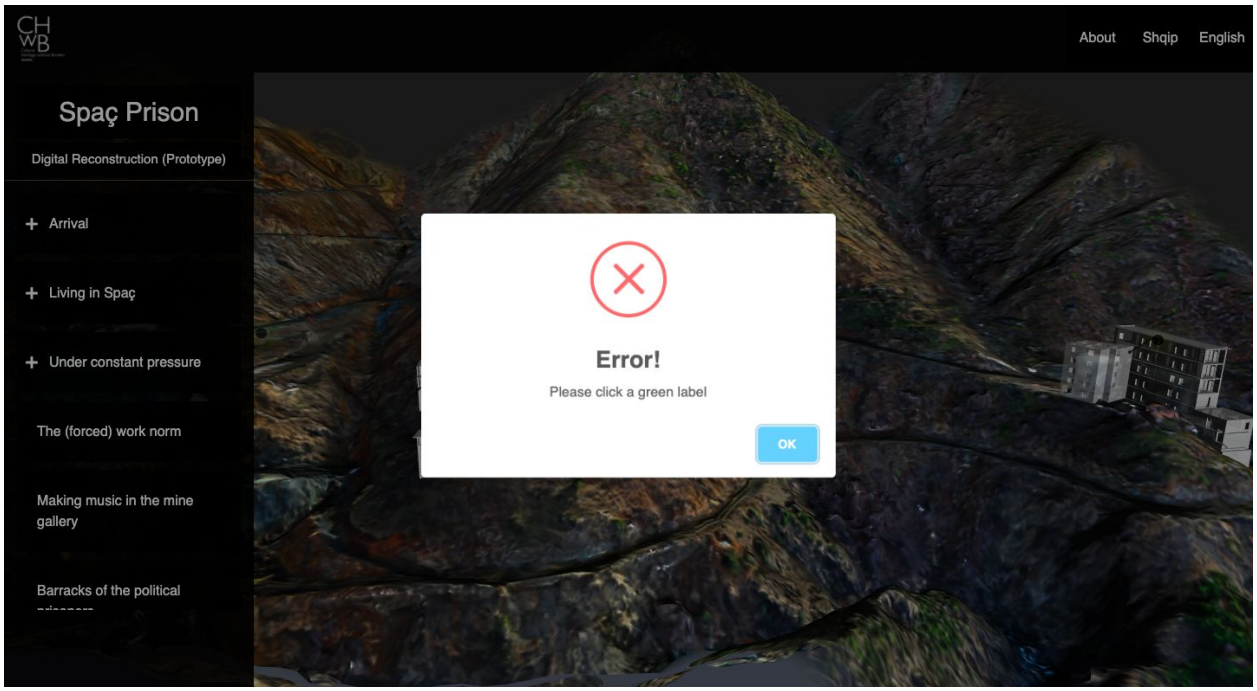

Figure 28: *Error message displayed when an unlinked tag is clicked*

3.3.2 Visual Improvements

Visual continuity was another concern that was referenced when discussing the site's possible key areas of improvement. Prior to the start of development, the team's sponsor and advisors mentioned how there could be a possibility of the site and model appearing unpolished and unfinished due to the lack of visual consistency. With various font choices and conflicting stylistic UI/UX elements seen throughout the website, such as different colored backgrounds, varying image sizes, and the inaccessibility of the sidebar menu on the model page, it was deemed a priority to update the look and feel of the website.

The older version of the website had a mixture of fonts - certain sub-pages were written in Times New Roman while others were in Arial font. This issue could be attributed to a plethora of CSS files which may cause stylistic elements to conflict, resulting in various and mismatching fonts throughout the website. With our project's main goal of introducing and educating the newer generations of Albanians on their fragmented past, it was important for our team to coax new users in using the site with visual appeals that appear friendly, rather than turning them away with unpolished stylistic elements.

Furthermore, the original sidebar on the master model page was one that was difficult to navigate. As shown in figure 29, appearing as a collection of floating elements, it was unclear to the team what the purpose of the original sidebar was trying to convey. Our team brainstormed several UI/UX improvements to make in order to smoothen out the visual appeal of the site and model. Some of these ideas included restructuring the sidebar in a different location to allow a larger view of the model itself, along with applying human computer interaction (HCI) principles to update the application's appearance.

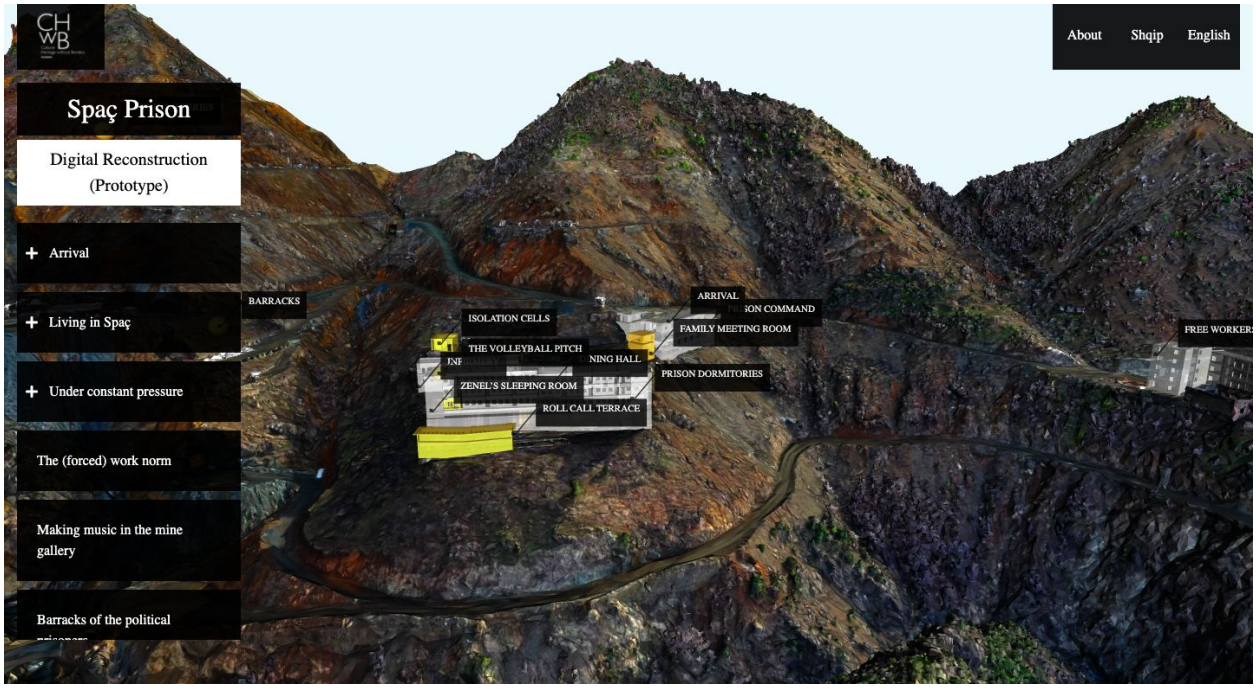

Figure 29: *Sidebar menu appearing as floating elements.*

It is essential to understand the role that human perception plays in regards to interacting with an application. Necessary for any website or mobile application, a decent UI design with a sound visual structure allows the user to understand and interact with the interface with relative ease. The concept of continuity states that once an element is introduced as a part of a series, the human mind will tend to continue the viewed series, alerting any varying elements as a mistake.[18] With the original varying fonts we had throughout the application, users were unable to form a predictable pattern, causing a visual conflict for users. Furthermore, the clashing of serif and sans-serif fonts created an overwhelming user experience. Times New Roman, a serif font, is part of a family of decorative fonts with ornamental finishes extending off the end of a letter's stem. Serif fonts normally convey a sense of history and tradition while sans serif fonts, such as Arial, appear cleaner and more precise - alluding to a sense of professionalism and simplicity. With this said, our team decided to resolve the visual continuity issues by initializing a standard font displayed all throughout the application - the Century Gothic sans serif font through the GoogleFonts library. This font was relatively easier to read as shown in the differences between figure 29 (previous version) and figure 30 (updated version).

It was also observed that there were multiple CSS files that were overwriting each other, resulting in the mixture of fonts. Our team was able to clean these files, separate them in order to prevent overwriting, and assign the new standard font that would be more fitting to the application.

The principle of continuity was also further showcased when introducing Gestalt principles into the remodeling of the application's appearance. The Gestalt Continuity Law explains how our brain experiences and groups together visual elements that continue in the direction of a line, thus not favoring stylistic elements with a lack of closure.[19] This is why our team decided to focus on the header and sidebar menu on the model page - with the original elements separated by vast amounts of space (figure 29), it was important to group together similar elements to portray belongingness and continuity (figure 30).

Figure 30: *The header and sidebar menu have been contained stylistically to sustain visual continuity*

In order to further the visual continuity between the application's subpages as well, the varying sizes of the 2D images displayed were standardized with a fixed height and width so that they would be of the same size. This is especially important since the principle of similarity suggests that visual elements which are of similar shape and size tend to be grouped together to

be seen as part of the same main and overarching element. Furthermore, in order to continue visual improvements, a dark background consistent with the main model page was added to all subpages, as shown in figure 31. This further helped to continue the Gestalt continuity principles since it was able to create a visual bridge of color continuity between the sub pages.

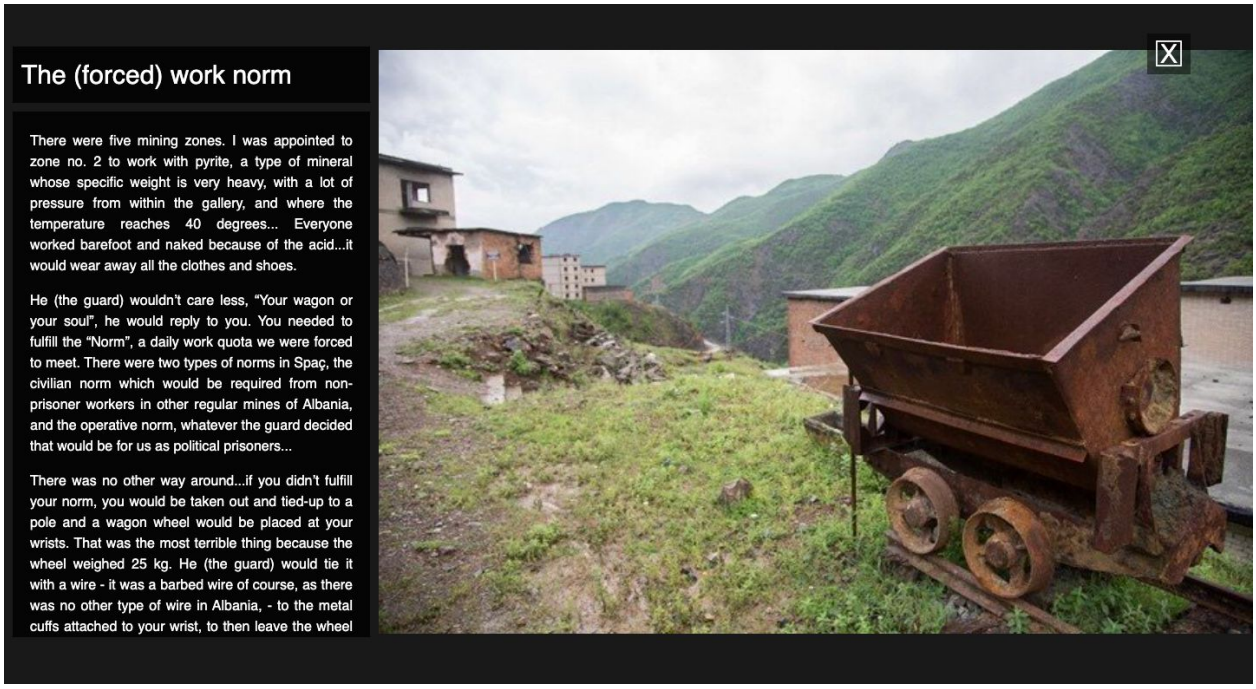

Figure 31: *A view displaying the consistent background between pages*

4.0 Survey Results and Findings

4.1 Conducting a Survey

An important thing to ensure upon completion of the project was that the implemented features actually served as an improvement and didn't worsen the user's experience. The group decided on conducting a survey in order to gather results regarding the improvement of the digital prototype. The reasoning behind conducting a survey, as opposed to having members of the project test features themselves, was due to bias. Additionally, group members were aware of issues within the original model, some of which included overlapping of labels. It is important to gather survey results from individuals who are unaware of the reasoning for feature

improvements. The results gathered from a survey described as such would serve to show an unbiased polling that could be used to further validate proof of improvements.

The survey was made and hosted through the Google Forms survey administration software. It consisted of 14 brief and voluntary questions, with only the first two questions requiring mandatory responses since our team wanted to ensure willing user participation and responses from those over the age of 18. Furthermore, our survey was sent out to two main community groups - the WPI undergraduate community, and colleagues/members of CHwB. The survey had 15 responders, however the group was only able to take into account the responses of 14, since one responder was under the age of 18.

Of the 14 questions, only nine questions pertained to the comparing and testing of the two versions of the application. These questions were further divided into three main sections - user preference between 2D version views, ranking of the displayed versions based on animated gifs, and open ended questions intended to be answered upon physically navigating between the old and newer version.

4.2 Methodology and Analysis

The progress made throughout the MQP was determined to have been an improvement from the originally supplied model. When comparing the original site (noted as version A) with the newly developed version (noted as version B), 73.3% of respondents preferred the overall look of version B. This shows a significant improvement in terms of the collective site visuals, specifically relating to stylistic continuity and the redesign of the main page's sidebar menus. When asked "In regards to the appearance of the terrain/map on which the main 3D prototype lies, which version do you prefer", 92.9% of respondents preferred the newly developed version over the original. This shows a stylistic improvement in relation to the actual model itself due to the implemented features of new terrain effects (section 3.2.2) and the fixing of clustered labels (3.2.1).

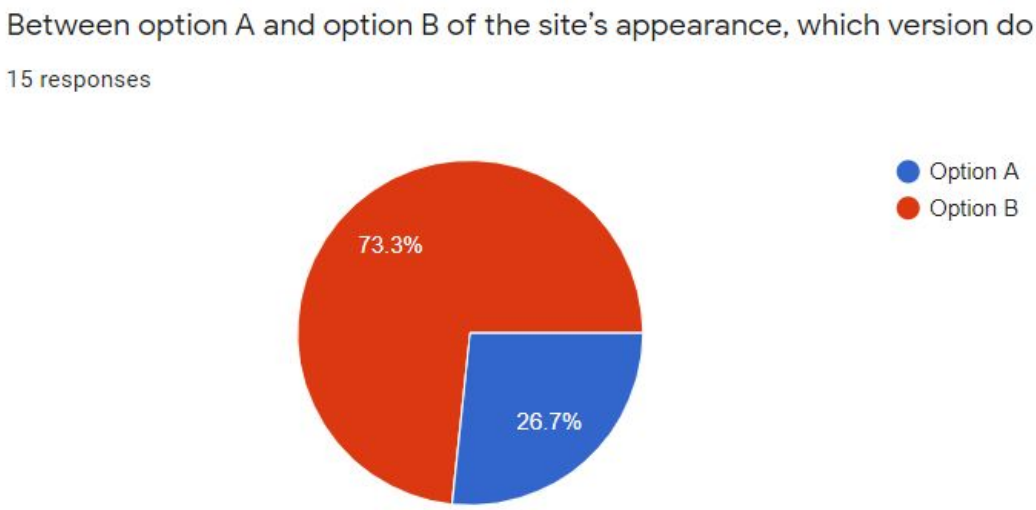

Figure 32: *A pie chart of responses for question #1 on the survey.*

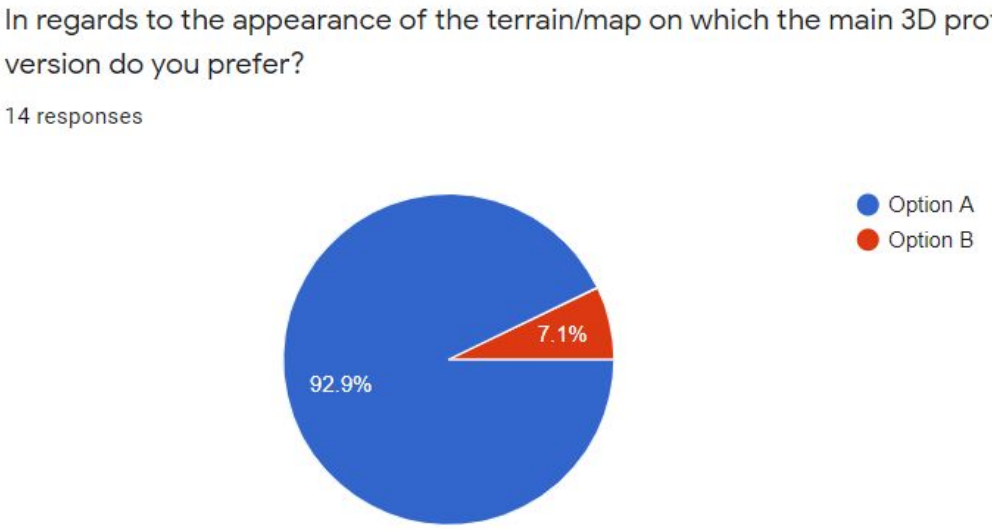

Figure 33: *A pie chart of responses for question #2 on the survey.*

When asked more generalized questions, the results showed that users favored the newly developed version of the site over the original as well. For example, when asked about their satisfaction with the newly developed site on a scale from 1-5, 14 out of the 15 responses responded with a rating of 4 or higher. However, when asked the same question about the original site, the results were relatively more mixed, with 12 out of the 15 responses ranked 3 or below. Similarly, when asked about label feedback, the new version of the site received better scores from survey respondents. When asked about preference in how each site alerted users of

clickable elements, the new site had 12/15 respondents give a rank of 4 or higher, whereas the original site was again mixed with 10/15 respondents giving a score of 3 or lower.

Once given a chance to actually interact with the site, 8/11 respondents reported faster load times for the newly developed site. Additionally, on a scale of 1 to 5, the original site had 9/12 respondents (75%) respond with a 3 or lower when asked "On a scale of 1 to 5 (1 being not as user friendly, while 5 being user friendly) , how do you feel navigating to sub pages". When the same question was asked about the newly developed site, 11/14 of the responses were ranked 4 or higher (78.5%).

5.0 Conclusions and Recommendations:

The possibility for future MQP teams continuing work on this project was brought up several times throughout the term. Knowing this, it feels essential to share what the group has learned so that future groups can apply this knowledge to their framework of the project. It became apparent that our goals were too ambitious for a one-term MQP. This led to the shifting of our scope well into the term. The goals that the team were not able to implement are further discussed in sections 5.1 and 5.2. Going forward, future groups should take note that one term is not a sufficient amount of time to take on several major tasks and features for this particular project. Rather, one task should be prioritized and polished while other tasks are made into stretch goals.

5.1 For Future Teams

Incorporating a text-based game element within the application was one of the highly suggested ideas. This feature would allow for a more interactive component that would further engage the user, encouraging them to explore the site on their own. Although our team expressed interest in the game component feature, due to the time restrictions presented by a one-term MQP, we shifted our goals to focus on the overall user ease of the application.
Should a future team take on this task, the game component feature should most definitely be prioritized as the main goal, placing all other tasks in the backlog. Gamified learning is a teaching methodology that promotes engagement and motivates users to participate beyond the scope of information given.[20] By utilizing an application's content to create a game-like element,

a level of curiosity is introduced that may help in an attempt to spread awareness and knowledge of Albanian history, especially in regards to the communist regime and the involvement of the Spaç Prison.

5.2 Looking Forward

After discussing with our sponsor and sponsoring organization, there were several ideas that were suggested, some of which our team wanted to further more than others. One of the more important ideas that our team wanted to recommend for the future of this project was the possibility of hosting the application on a mobile device. This idea had been initially brought up by CHwB in the earlier stages of our project's development, especially since they were previously considering shifting gears to cater the application towards mobile devices.

Our recommendation is to halt development on the website-based application and switch gears to allow it to be more application-based. This is due to the technical complexity that arises later in development when trying to convert a web app into a mobile app. For example, if attempting to convert the web app later in production, the developer could run into several performance and visual issues, possibly derailing the project and adding countless hours to reimplement features catered towards application-based development. However, should the model be developed into an application, further production from that point would then be easier to roll out to all platforms. These may include mobile devices, as well as various operating systems.

5.3 Conclusion

Our project aimed to improve upon the digital prototype of the Albanian Spaç Prison in efforts to draw attention to the monument as a historical site. Several features were implemented to improve upon both the 3D model and the user interface. The results of our online survey showed that our team had made both stylistic improvements throughout the model and site, as well as faster loading times in displaying the model.

With the improvement of the application, future teams will now have a better footing to advance from, further improving the experience of those using the application as a tool to learn about the history of Albania's communist regime.

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Appendix :

Digital Prototype of the Albanian Spaç Prison (MQP)

This survey is being conducted by a team of two undergraduate students, Rory Sullivan and Anagha Late, studying at Worcester Polytechnic Institute (WPI) in the United States. Expanding upon a previous team's project, our team set goals to further implement a series of features and visual improvements to the Albanian Spaç digital reconstruction project. Sponsored by the Albanian Cultural Heritage Without Borders program, this project's goal is to draw attention to the Spaç Prison as a historical site. Currently, there is a disconnect between older generations recounting the historical traumas experienced in the Albanian communist regime, and the newer generations understanding the significance of the site and history.

The implemented features were aimed to make the model more aesthetically pleasing, the model more compact and light, and improve the user interface (UI).

Currently, our team is conducting a survey to gauge the effectiveness of both the technical and visual advancements that have been made. The survey will take approximately 10-15 minutes to complete and your participation in this survey is completely voluntary, allowing you to withdraw at any time.

In this survey, our team will be asking a few brief questions, two of which involve the user switching between tabs containing the two separate versions of the application. The results gathered will aid in further development of the site by guiding the implementation of features towards the most ideal solution.

The application is only intended to viewed on a computer browser. All other platforms are not supported (these include mobile devices)

Your participation is greatly appreciated and the responses will remain confidential. If interested, a copy of our results will be available on the project center website at the conclusion of the study. If you have any further questions, please feel free to email our team at gr-spac-prison-mqp@wpi.edu

* Required

1. Do you wish to proceed with the survey? *

Mark only one oval.

- ◯ Yes
- ◯ No

2. Are you above the age of 18? *

Mark only one oval.

- ◯ Yes
- ◯ No

General Questions - Preference

The following two questions pertain to asking your preference of one version over the other

3. Between option A and option B of the site's appearance, which version do you prefer?

Mark only one oval.

◯ Option A

◯ Option B

4. In regards to the appearance of the terrain/map on which the main 3D prototype lies, which version do you prefer?

Mark only one oval.

◯ Option A

◯ Option B

General Questions - Ranking

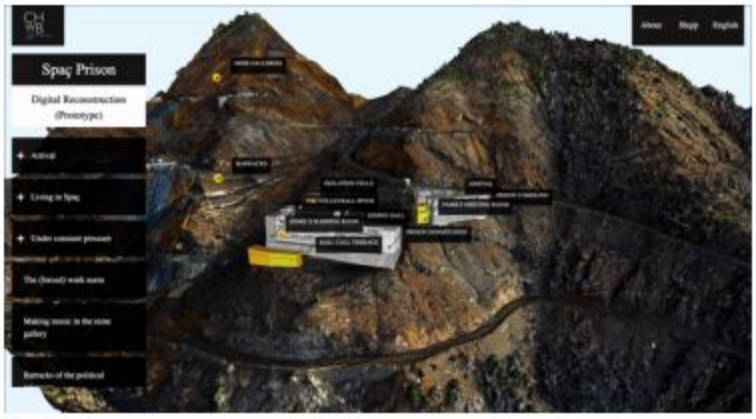
The following questions pertain to asking you to rank your satisfaction / preference in regards to a specific version

5. In regards to content exploration, please rank your satisfaction of this version (Option A) on a scale from 1 to 5 (1 being not satisfied, 5 being very satisfied.)

Mark only one oval.

	1	2	3	4	5	
Not Satisfied	◯	◯	◯	◯	◯	Very Satisfied

6. In regards to content exploration, please rank your satisfaction of this version (Option B) on a scale from 1 to 5 (1 being not satisfied, 5 being very satisfied.)



Mark only one oval.

	1	2	3	4	5	
Not Satisfied	◯	◯	◯	◯	◯	Very Satisfied

The digital reconstruction of the Spaç Prison incorporates some labels that are clickable, while others are not. In the following example, 'Zenel's Sleeping Room' is clickable while 'Prison Dormitories' is not.

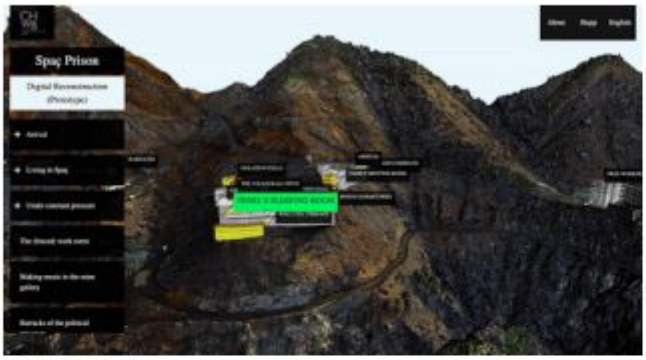
The following two questions pertain to your preference for the visual aid provided in regards to clickable and non-clickable labels

7. Please rank your preference on a scale from 1 to 5 in regards to how this specific view alerts the user of a clickable element? (1 being no preference, 5 being strong preference)

Mark only one oval.

	1	2	3	4	5	
No Preference	◯	◯	◯	◯	◯	Strong Preference

8. Please rank your preference on a scale from 1 to 5 in regards to how this specific view alerts the user of a clickable element? (1 being no preference, 5 being strong preference)



Mark only one oval.

	1	2	3	4	5	
No Preference	◯	◯	◯	◯	◯	Strong Preference

General Questions - Navigation

In this section, our team will ask you to switch between two tabs, each with a different version of the app. Please briefly fill out the following questions

Link for Version 1: https://www.spacprison.com/#/home

Link for Version 2: https://mqp-spac-prison.herokuapp.com/#/home

9. Upon first launching the applications, what were your thoughts on the model load times? Be sure to compare both versions in your brief answer

10. On a scale of 1 to 5 (1 being not as user friendly, while 5 being user friendly) , how do you feel navigating to sub pages in link 1 / version 1?

Mark only one oval.

	1	2	3	4	5	
Not as user friendly	◯	◯	◯	◯	◯	Very user friendly

11. On a scale of 1 to 5 (1 being not as user friendly, while 5 being user friendly) , how do you feel navigating to sub pages in link 2 / version 2?

Mark only one oval.

	1	2	3	4	5	
Not as user friendly	◯	◯	◯	◯	◯	Very user friendly

Final Steps

Thank you for your time! The survey has been concluded and your participation is greatly appreciated

12. Do you have any questions, comments, or concerns?

_____

13. Would you like to receive a copy of your survey results at the conclusion of our study? (Your results will be sent to you via email at the conclusion of our study.)

Check all that apply.

- ☐ Yes
- ☐ No

14. If you answered "Yes" to the two previous question, or would like a response to any question, comment, or concern, please indicate the best email for us to reach you.

_____