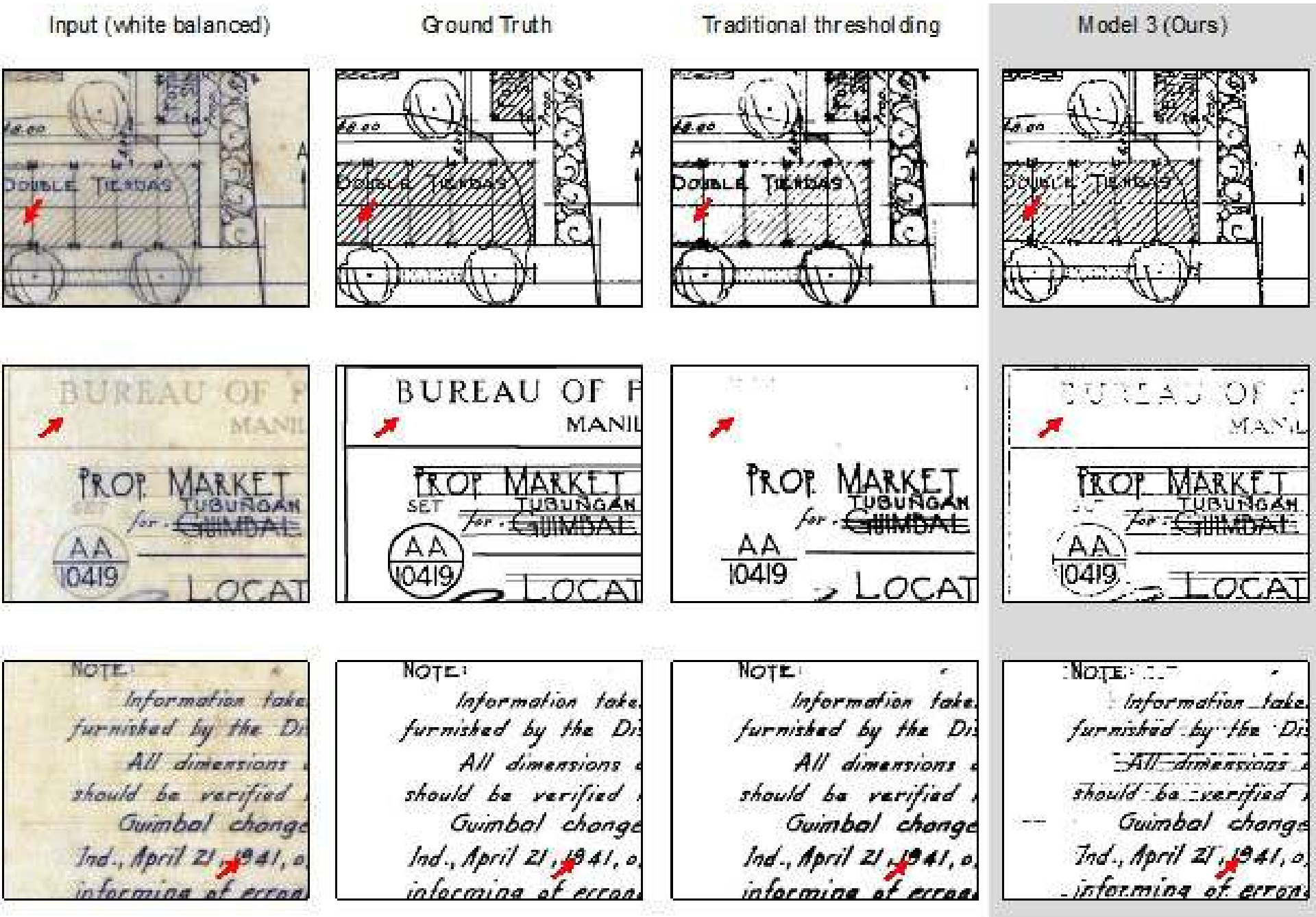


Figure A. Close comparison of our AI model to traditional method. We see how our model was able to detect fine lines than the traditional method.

Architectural Archiving and A.I.

Turning Historical Architectural Designs into Line Arts Using Artificial Intelligence

Text by Mark Jeremy Narag and Maricor Soriano

We created an artificial intelligence (AI) model that automatically converts our historical Philippine architectural designs into line art. As old designs age, they turn yellow, and stains of various degrees also accumulate on the designs. While converting them into line art can be done manually in Photoshop, editing multiple designs becomes tedious. Traditional binarization methods of thresholding can automatically convert them into line art, but they fail to detect the fine lines of the drawings while emphasizing the stains. To address these issues, we manually cleaned a single design first. Since the image is large, we cropped thousands of small patches from it. Now, with thousands of dirty-to-clean pairs of images, we trained the AI model to understand the underlying transformation between the pairs and learn the task of converting an old design into line art. Our results, illustrated in Figures A and B, demonstrate how our model outperformed the traditional thresholding technique. It successfully detected the fine lines while ignoring the stains present. Additionally, our model can clean one design in less than three minutes.

Back in the day, before the rise of modern technology and the advent of AutoCAD, architects drew their designs on paper or canvas. Over time, it is inevitable for these architectural drawings to "age." Factors such as exposure to UV rays and pollution led to the natural yellowing of the paper (Carter, 1996), along with the accumulation of dirt and stains. Take a look at Figure 1.

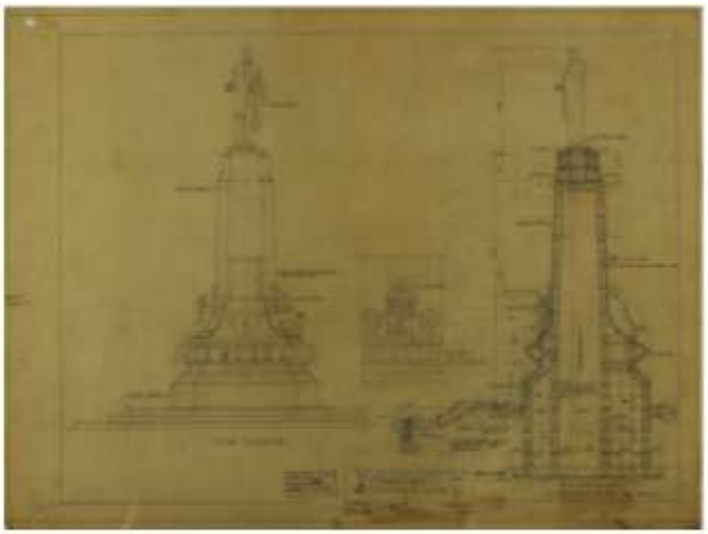
The problem. What if we could restore this drawing to its original beauty? Besides, we can easily distinguish the line drawings from the yellowed and stained background. This is feasible in Photoshop. However, if we edit multiple drawings, say 100 or 500, it will be a tedious task and may take us forever. I tried to manually edit a drawing using GIMP in Figure 2 and it took me 21 hours to finish!

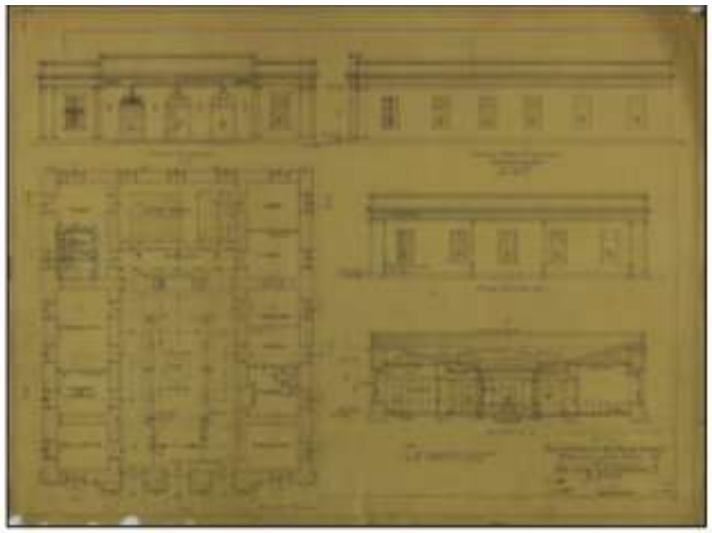
Mark Jeremy Narag

Mark Jeremy Narag is an instructor and a PhD candidate in Physics at the National Institute of Physics, UP Diliman. He earned his BS in Applied Physics in 2019 and his MS in Physics in 2021. He specializes in image processing and artificial intelligence (AI) applied to cultural heritage documents. His previous works include distinguishing Juan Luna's paintings from those of other contemporary artists and unveiling a large-scale artistic influence map among Impressionism, Expressionism, and Surrealism art movements by identifying visually similar paintings. Currently, his PhD research focuses on virtually restoring degraded historical documents such as architectural drawings, Spanish-era maps, and paintings using deep learning models.

Maricor Soriano

Maricor Soriano is a Physics professor at the National Institute of Physics, UP Diliman, leading the Video and Image Processing Group. Her laboratory addresses multi-disciplinary challenges by developing both hardware and software imaging solutions. She has collaborated with parasitologists and computer scientists on malaria imaging, with museum researchers on cultural heritage conservation, and with sports scientists on video-based athlete performance tracking. Her cross-disciplinary contributions to applied physics earned her the 2013 Outstanding Women in the Nation's Service Award (TOWNS).





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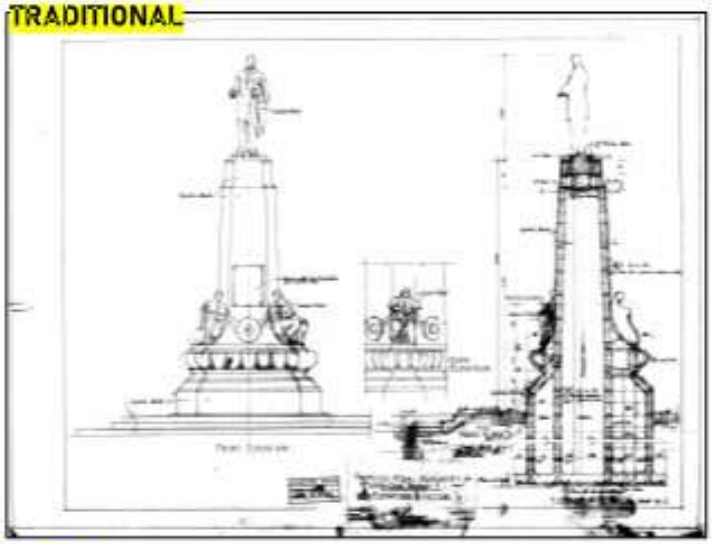

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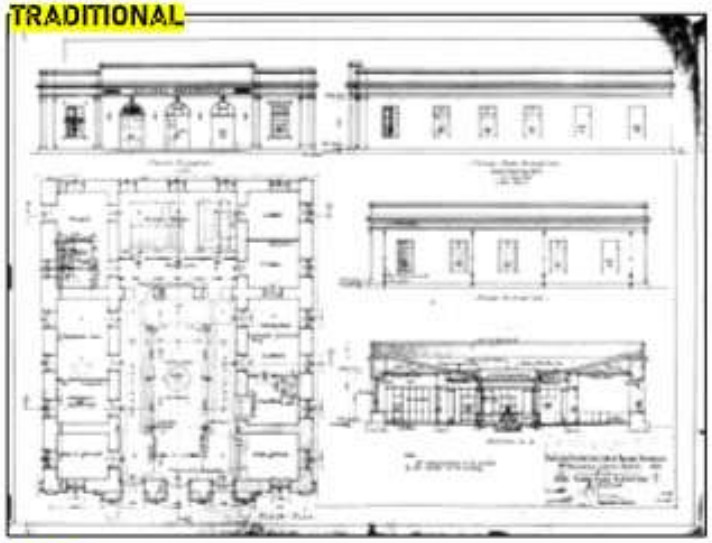

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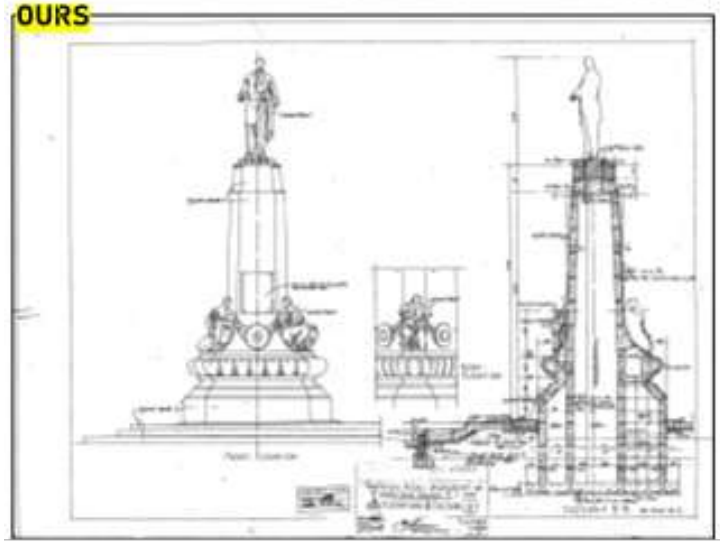

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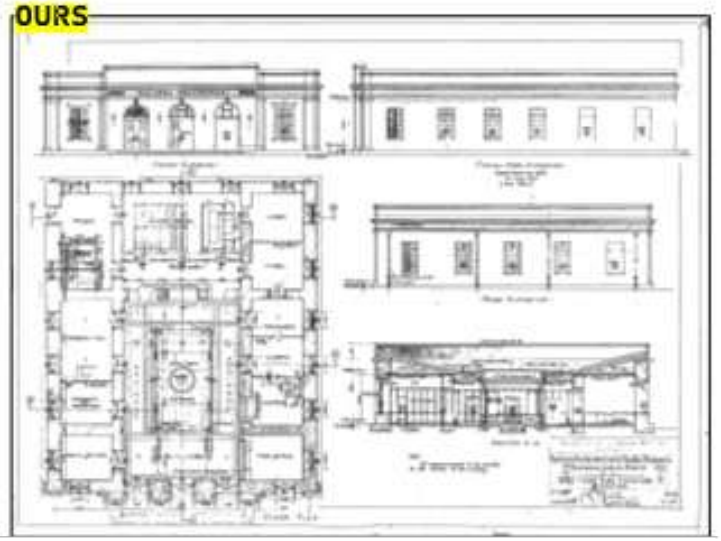


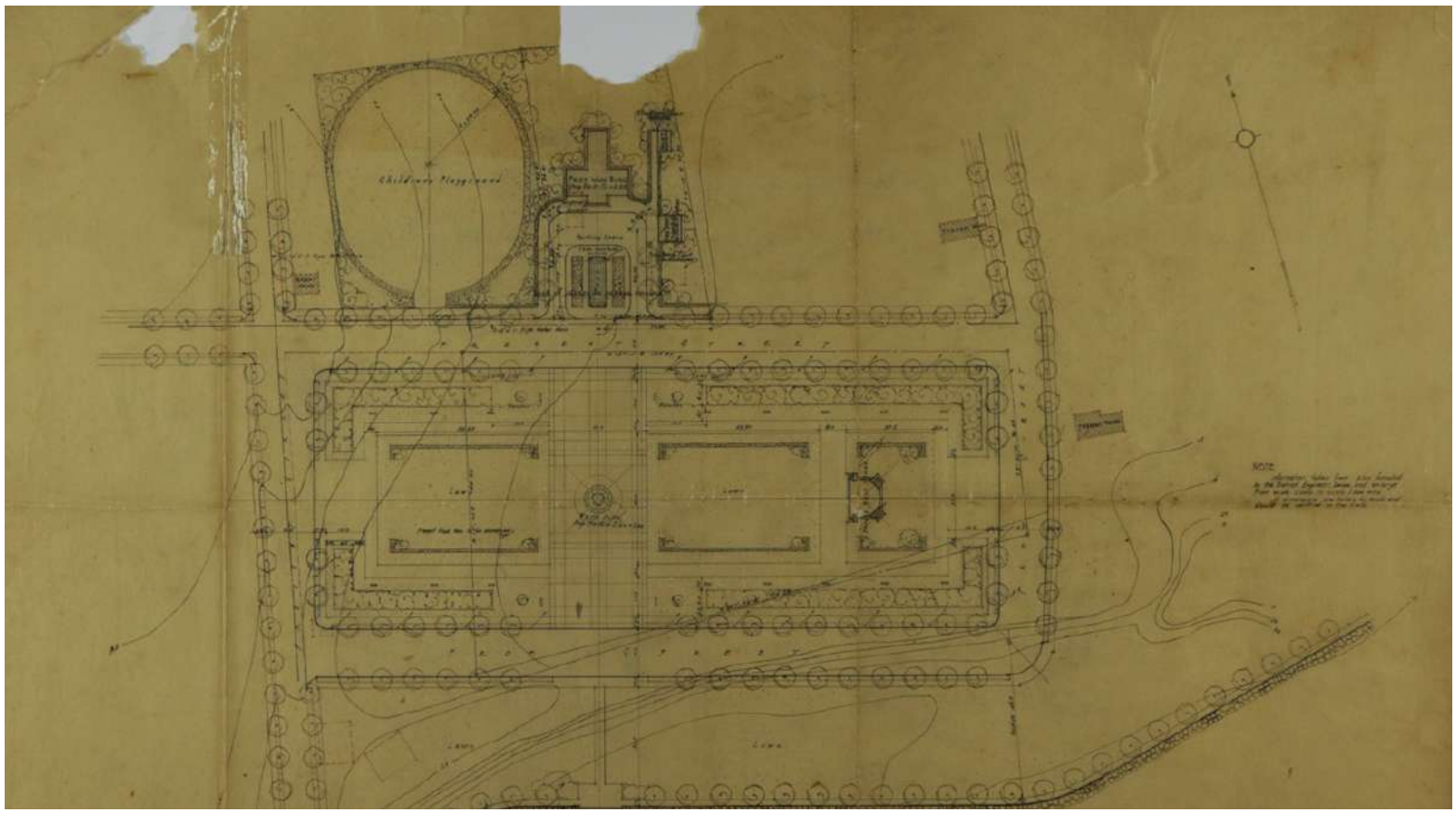


Figure B. (Left) Rizal Monument in Sta. Cruz, Davao (1936). The traditional method faintly detects the sculpture of Rizal but heavily detects the stains at the bottom of the vellum. In contrast, our model focuses on the fine lines and ignores the stains. (Right) Bacarra Presidencia, Ilocos Norte (1936). Similarly, the traditional method fails to

Figure 1. (Above) Digitally scanned Rizal Monument in Sta.Cruz, Davao (1936). Dimension 6400 by 4509 pixels. Originally drawn in vellum, the design has yellowed over time. Foxing, pronounced creases, and other stains are also present.

The solution. In this study, we built our artificial intelligence (AI) model that can convert our old Philippine architectural drawings into their line art form. We want to create a model that can automatically edit any drawings without the painstaking manual photoshopping.

AI works like teaching a kid to differentiate an apple from a banana. We start by handing them an apple and a banana, letting them feel, smell, and taste the difference. Then they catch on to the distinct colors, shapes, and flavors. For AI, we show it pictures of apples and bananas. Humans can nail it with only one sample shown, but AI needs to see thousands of samples before it can distinguish the two. Humans rely on intuition while AI relies on massive data.

In the context of this study, we train an AI model by exposing it to thousands of "dirty" to "clean" images. Dirty refers to the original scanned design in Figure 1 while clean is the traced version in Figure 2. But how to generate thousands of samples? Since the scanned images are large (6400 by 4509 pixels), we crop thousands of overlapping small patches from them. In total, around 16,000 patches were cropped which will be used to train the AI model. Shown in Figure 3 are samples of cropped patches in varying sizes.

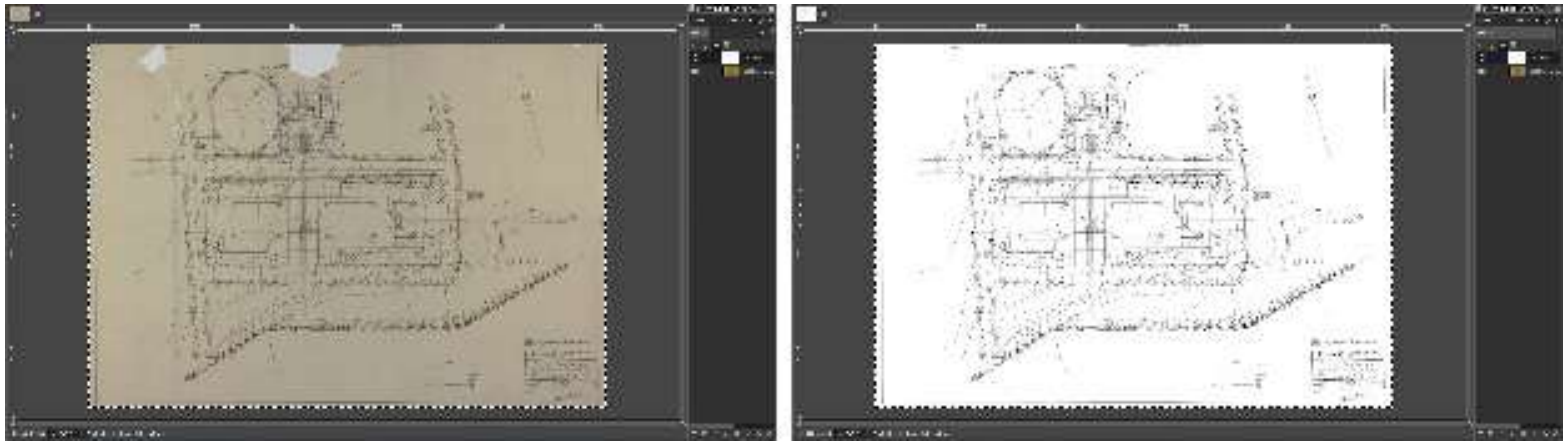


Figure 2. Manually tracing the architectural design in GIMP. It consists of two layers—the top layer is the clean version while the bottom layer is the original. On the left, the opacity is reduced on the top layer to view the bottom layer for tracing. The final cleaned version is shown on the right.

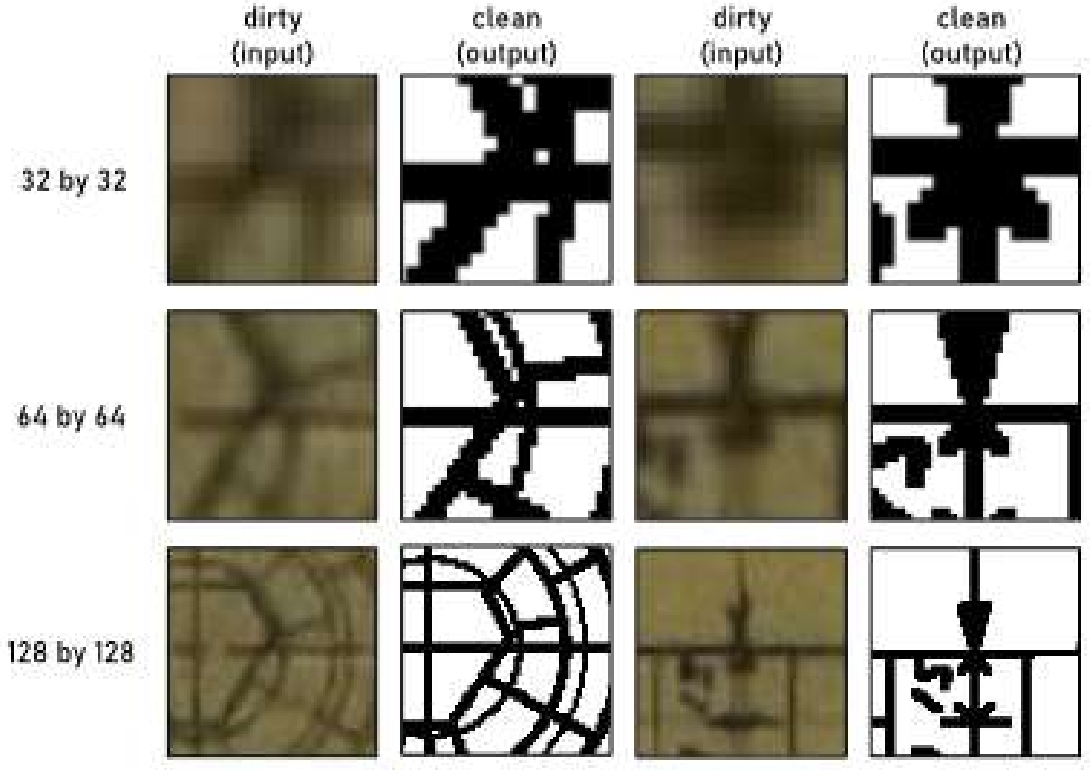


Figure 3. Samples of cropped patches of varying sizes.

The AI models. We created several AI models using a convolutional neural network of varying layers and input sizes. We trained it using the thousands of input-output pairs in Figure 3. For pre-processing, we white-balanced the images first. We then evaluated the performance of the models and determined the best model. To visually assess the best model, we show in Figure 4 the comparison of the ground truth to the output of our best AI model. For the ground truth, we manually cleaned just a portion of another design—Tubungan Market in Iloilo, 1935.

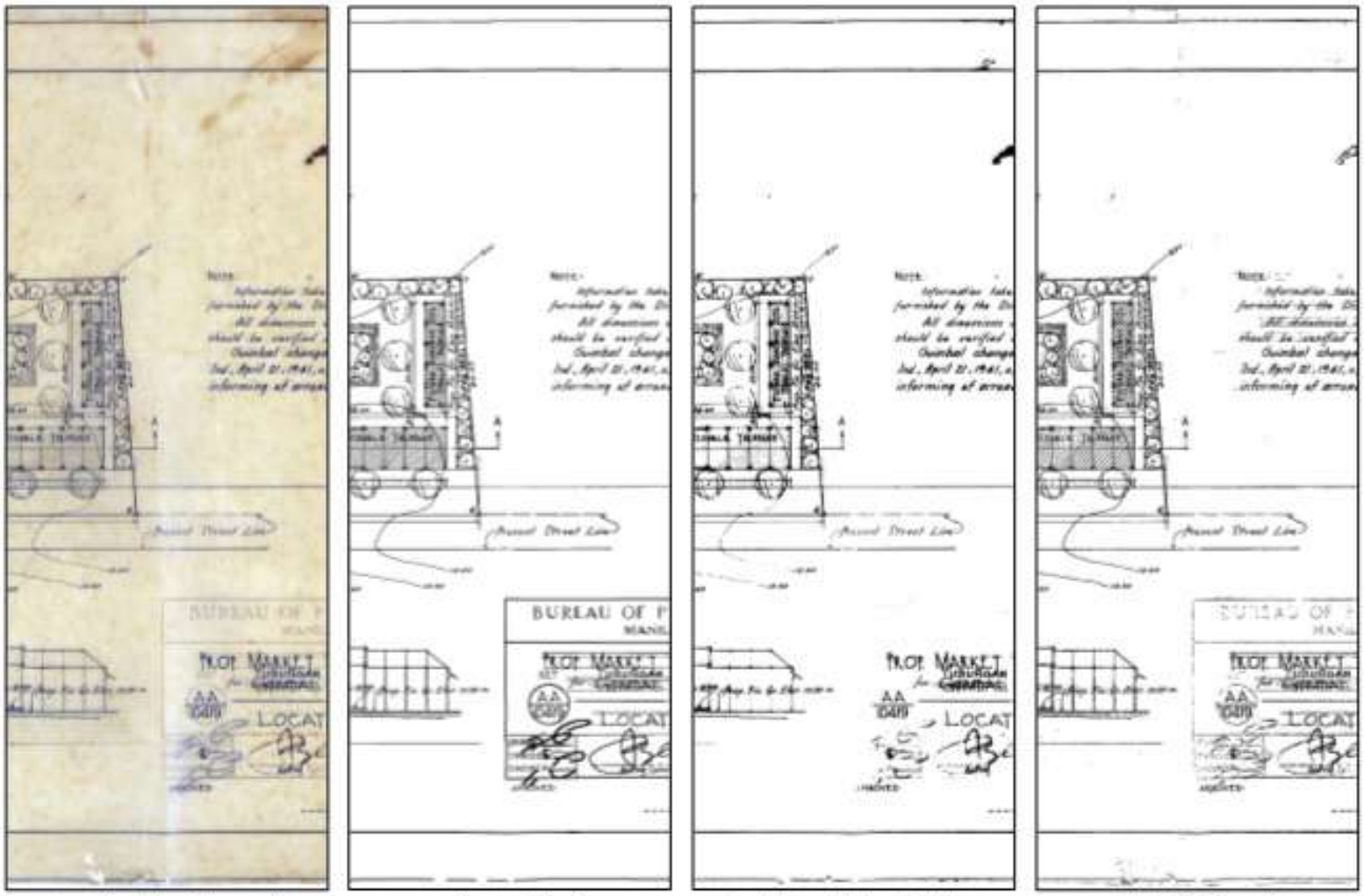


Figure 4. Result of Model 3 in comparison to the ground truth and traditional thresholding.

For close comparison, the pros and cons of our model are illustrated in Figure 5. On the first and second rows, our model successfully detects fine and faint lines of the drawings where the traditional model fails. For fairness, the third row showcases how our model identifies penciled guides that should not be present. Illustrated in Figures 6–9 are more examples.

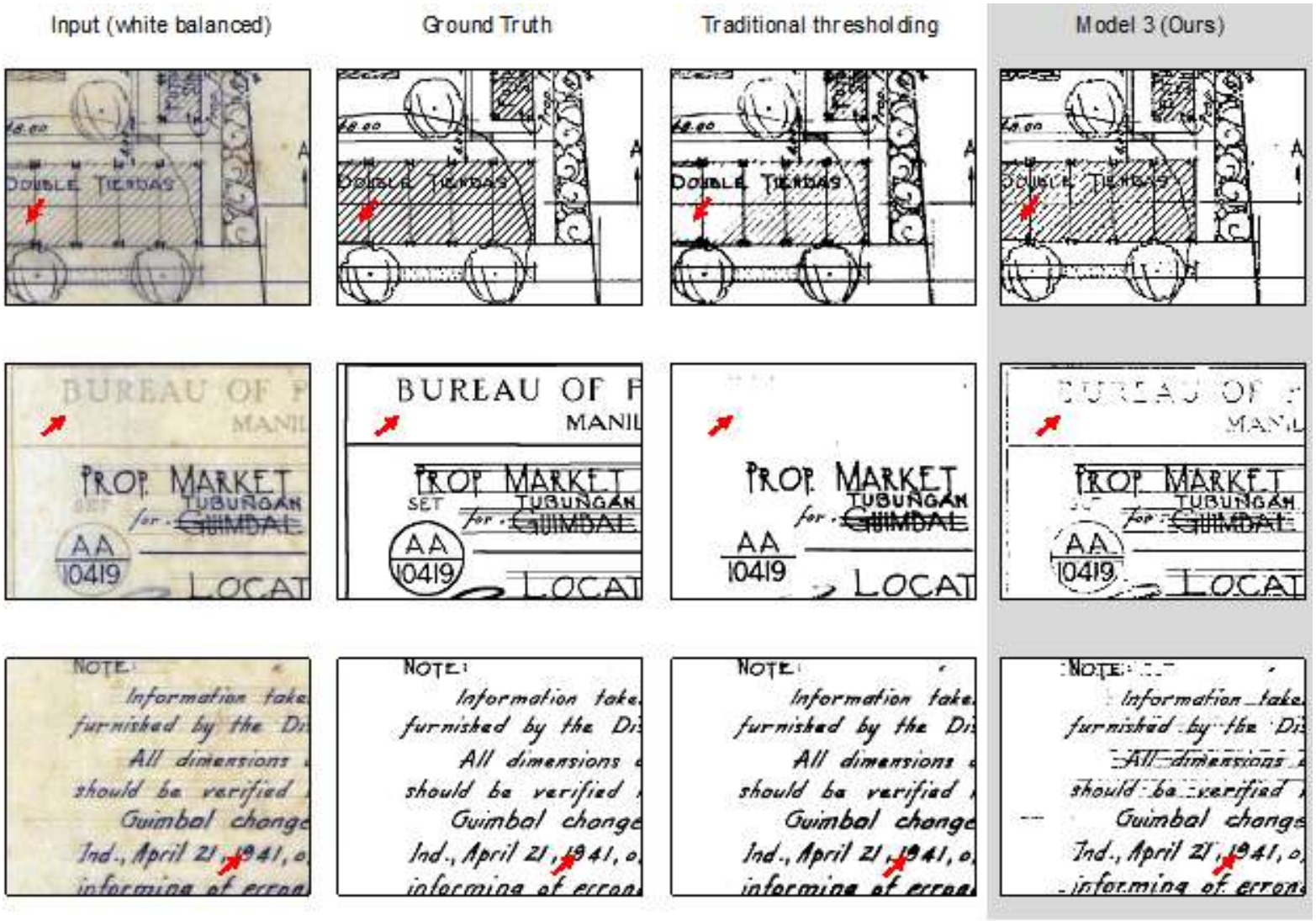


Figure 5. Close comparison of our AI model to traditional method.

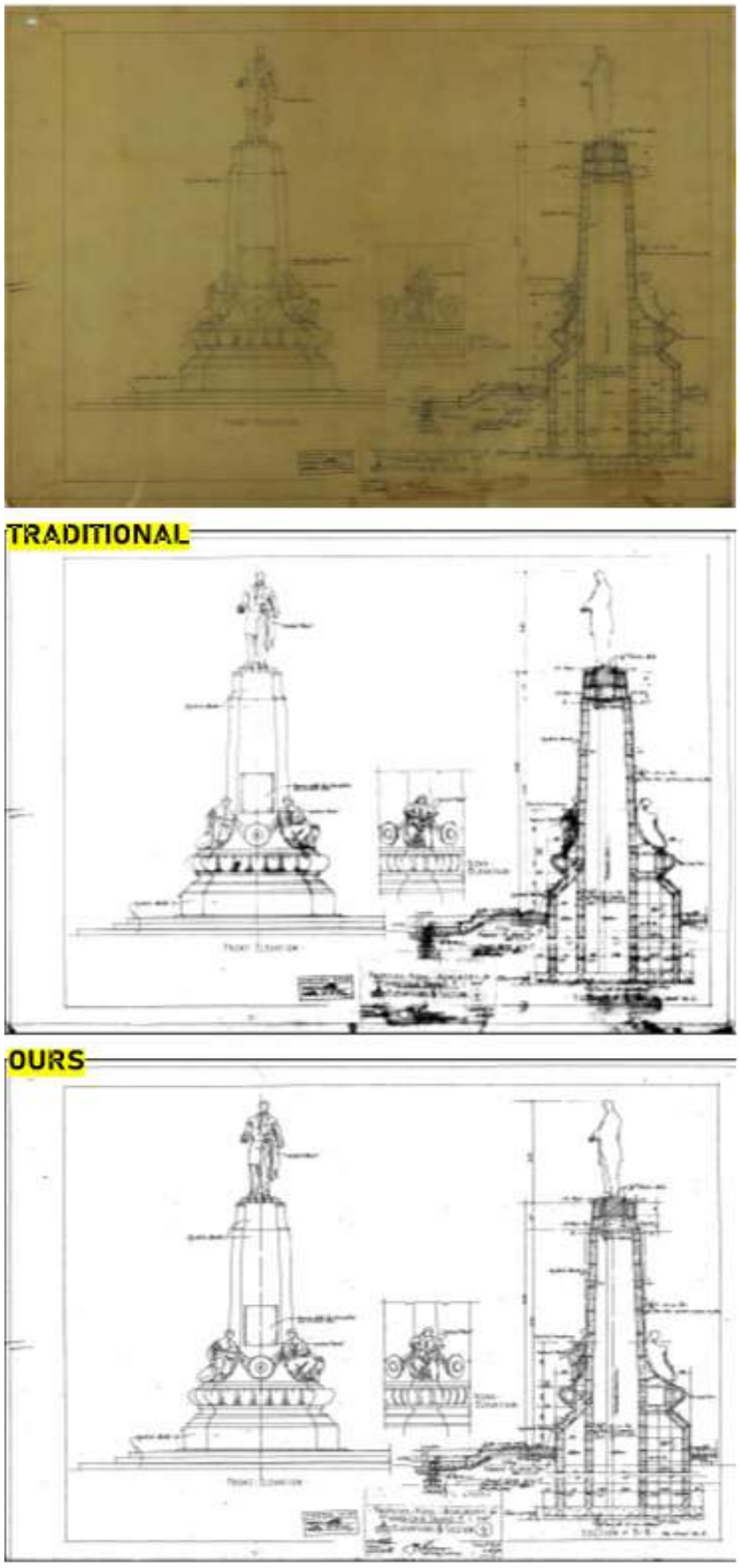


Figure 6. Rizal Monument in Sta. Cruz, Davao (1936). The traditional method faintly detects the sculpture of Rizal but heavily detects the stains at the bottom of the vellum. In contrast, our model focuses on the fine lines and ignores the stains.

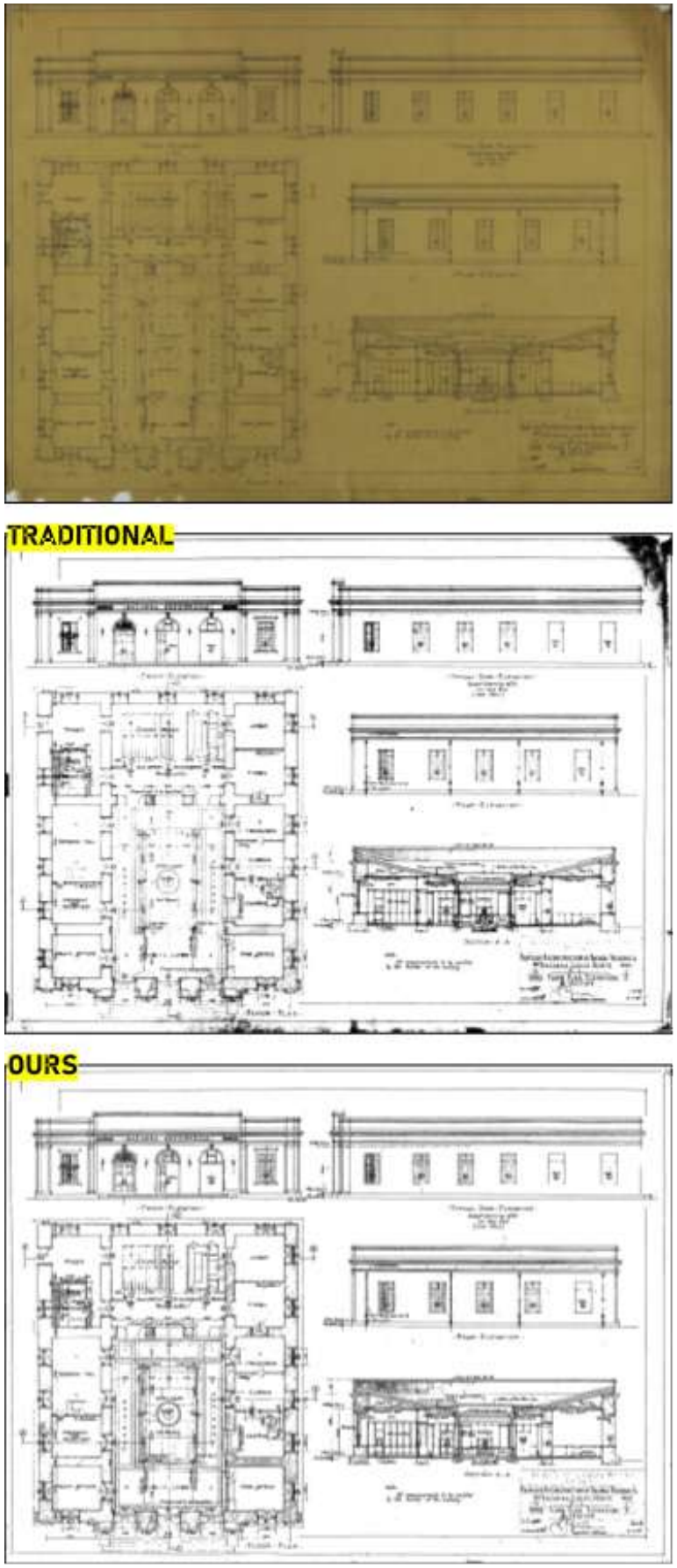
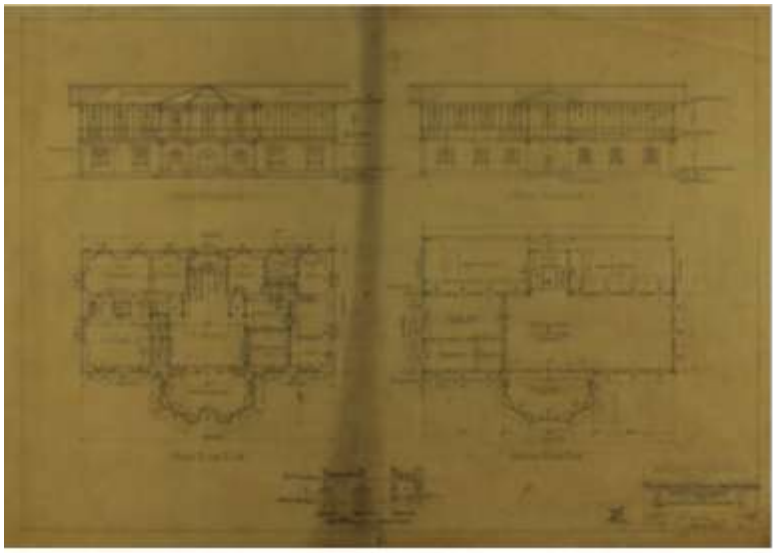
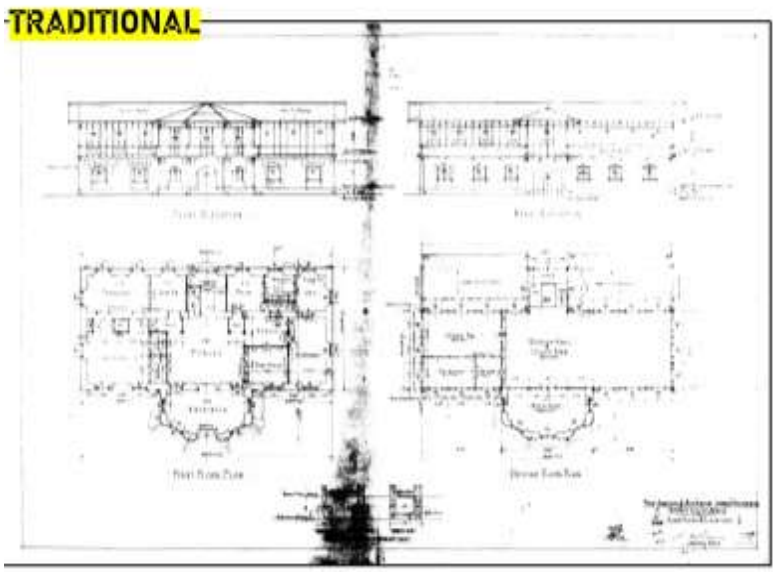


Figure 7. Bacarra Presidencia, Ilocos Norte (1936). The traditional method fails to detect fine lines yet emphasizes the stains, both of which our model can resolve.





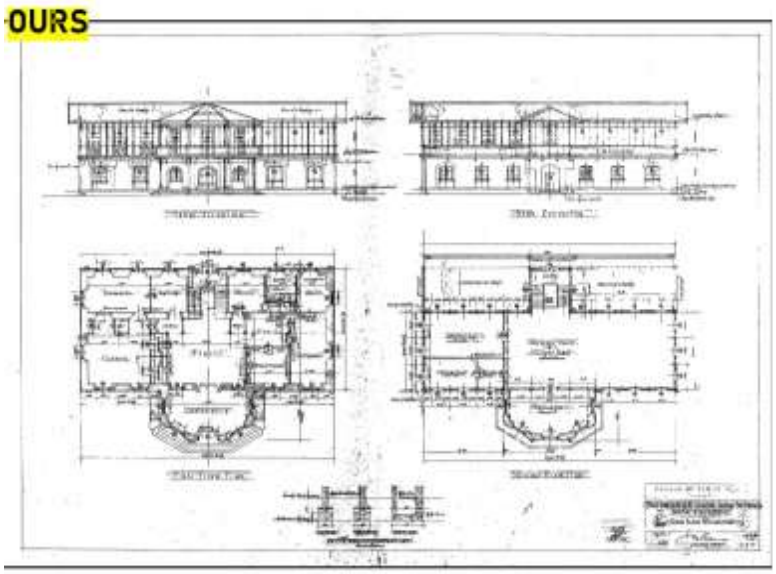
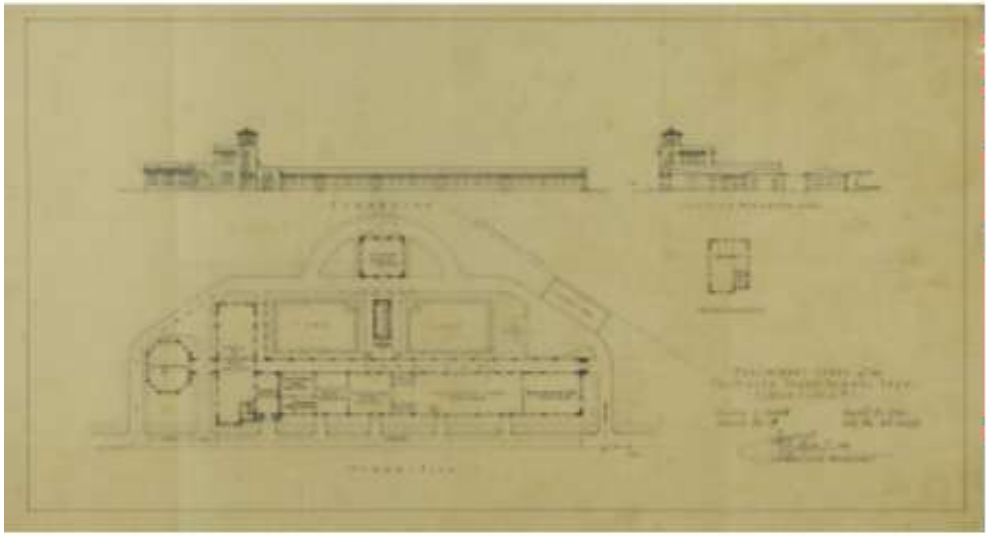
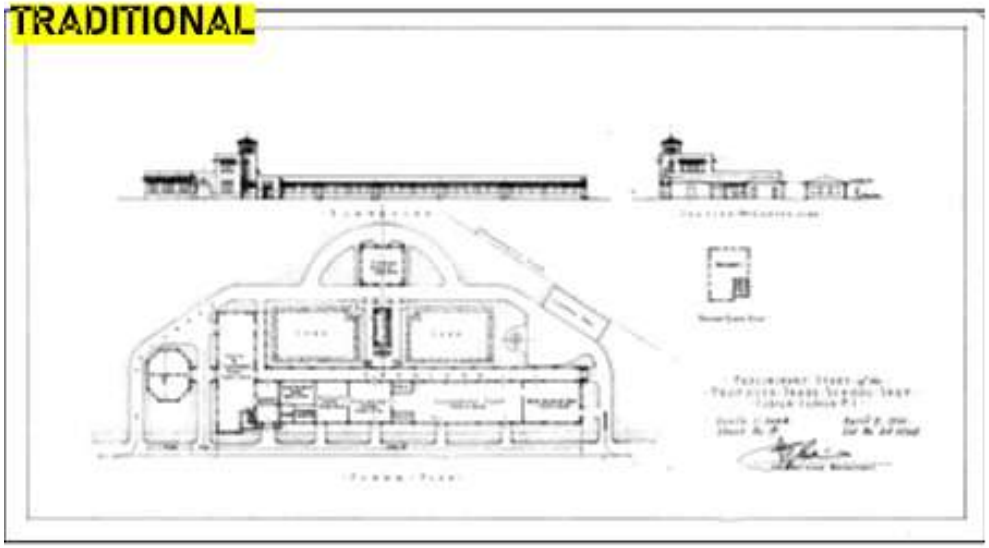


Figure 8. Sabbat Presidencia, Ilocos Norte (1932). For a heavily stained design, while our model was not able to eliminate the stains, it provided significantly better results than the traditional method.





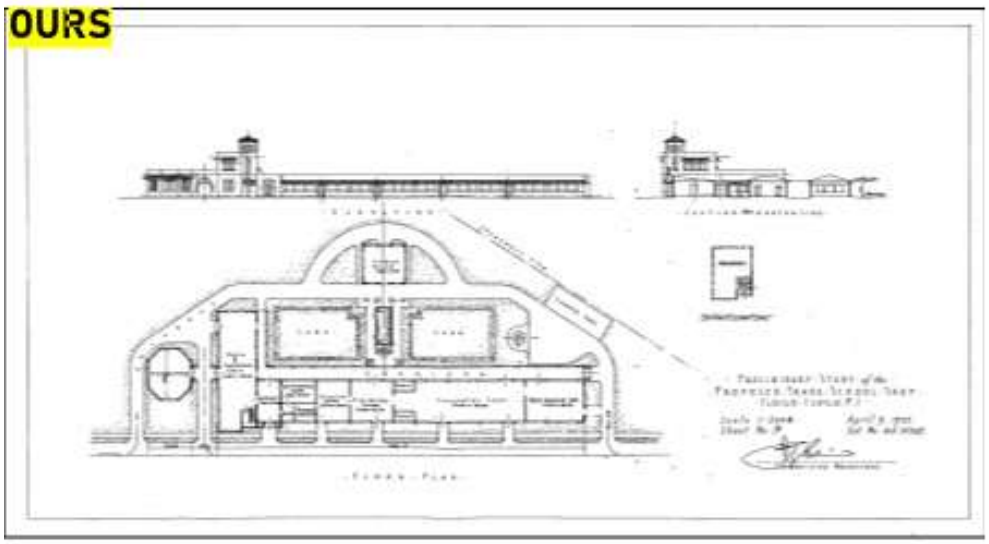


Figure 9. Trade school shop in Iloilo (1935). This is an example of a clean design where there are no noticeable stains. We can see that both our model and traditional method were able to clean it. However, upon closer inspection, we see how our model was able to draw all the fine lines and even the dots of the drawings better than the traditional method. The traditional method tends to merge compact thin lines as one thick line, which our model was able to separate.

In conclusion, our AI model surpasses traditional thresholding techniques in transforming historical architectural designs into line art. The traditional method tends to underdraw faint and thin lines while overemphasizing stains, both of which our AI corrects. Although hints of stains may remain in severe cases, these can be manually cleaned if necessary. Nevertheless, our AI demonstrates automatic cleaning without the need for meticulous photoshopping, accomplishing the task for an entire drawing in under three minutes.

References

Carter, H. A. (1996). The chemistry of paper preservation: Part 2. The yellowing of paper and conservation bleaching. Journal of Chemical Education, 73 (11), 1068.