TEKNOFEST
AVIATION, SPACE AND TECHNOLOGY FESTIVAL

TECHNOLOGY CONTEST FOR HUMANITY
PROJECT DETAIL REPORT

PROJECT CATEGORY: Health and First Aid/Disaster Management/Social Innovation/Disabled Frie ndly
PROJECT NAME: Determination of Disaster Relief Center Location using Integrated Lights Out Puzzle Solution

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Application ID: 68102

TEAM LEVEL: University-Graduate

1. Project Summary (Project Description)

Flood has been a destructive disaster in some countries in the world, thus we would like to use a program that can help people after a flood occurred. We propose the idea of "Center of Mass" to analyze the area, using AI detection for the building detection by Tensorflow Model Analysis method (TFMA), and locate the center among people in the area to be a relief center. Also, users can also choose the number of relief centers and we will locate the optimal location of relief centers in that area. This program will be beneficial for the government who can play a big role to help the community as a whole. However, there are some limitations in our program that can cause some difficulties while using.

2. Problem/Issue:

One of the most commonly found natural disasters in Southeast Asia is flood. The main damage from flood is devastating; as water fills every household and infrastructure causing a calamitous amount of damage; along with disabling rescue attempts to the affected civilians stuck inside the flooded area, causing them to suffer from dehydration, starvation, unhygienic environment, and much more as time goes by. Therefore, we came up with an idea to determine the optimal location of relief centers, which give out resources to those affected. AI detection of households based on residential areas from satellite imagery and the idea of the Center of Mass will be utilized in our model. Through adopting our model, an efficient rescuing process can be made due to the most effective position of the relief center.

The current solution to this problem in a more wealthy country usually is to have the population themselves prepared for a flood to occur; however, that's not the case in most countries. Instead, the method for relieving civilians caught in a flood is to build a central center outside the flooded zone and deliver resources to the affected by boats. This may seem like a proper way to deal with the situation, which it is; however, it is inefficient due to the lack of plans to calculate the numbers of relief centers, and calculate the amount of supply in each center for each household. This is a huge flaw as resource management is crucial when a disaster strike. Judging from a real scenario where resources are limited and the amount of civilians are extensive, building a single relief center somewhere near the area to divide supply might sound reasonable, but by further branching the relief center and placing them in a strategic point can achieve greater efficiency of easing the masses in less time by following a calculated pathway. Therefore, by further branching the relief center and placing them in a strategic point; we can greatly increase the efficiency of spreading supply to those afflicted by the situation.

3. Solution

Our project is designed to solve the problem of finding the best position for establishing the disaster relief center for flooding. The optimal position makes the disaster relief process be managed equally to everyone in the area and the least wasteful in any aspect of resources. In this problem, it is essential to make computers understand the geographical area. It needs to understand the place where people are living and how many people are living in that area. To accomplish this problem, we apply Polygon Segmentation, TensorFlow model analysis (TFMA) for the building detection process. The input satellite image format must be the non-tilt image from google earth pro. The input area must have one grid size in the google earth pro (around

400x400 square meters) at an elevated altitude of 1.1 kilometers from the ground with a resolution of more than 300x300 pixels. The reason that we need to fix the input image is that our model is still sensitive to the differences of the image. If the input image is not similar to our database enough, it will have less performance and more error. In the training step, each stuff in the picture will be segmented by polygon segmentation for an annotation, based on the hypothesis that the building would have the geometry shape, such as rectangle, pentagon, and hexagon. The picture will be montaged into a black and white dimension as in figure 1.

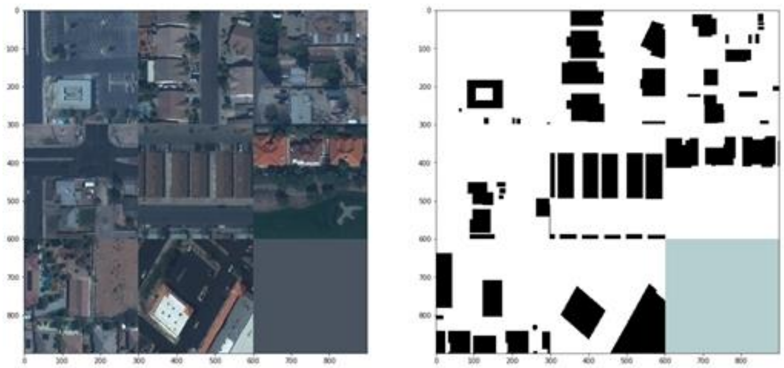


Figure 1. (Left) the input satellite image (Right) the same image after the polygon segmentation

Then we do the Tensorflow model analysis (TFMA) for the building detection with around 280000 satellite images as a database (This number includes train, validation, and test for model) [1]. The sample of the model performance is shown in figure 2. In this case, we assume the number of people living in each area by the calculation compare with an area size for 1 person require for living (at the moment we based this number by a data statistic from Japan) [2] The example of the satellite image processing is shown as in figure 3.

Figure 2. This is the picture during testing the model after we have done training it. (Left) the input satellite image (Right) the same image after the TFMA

Figure 3. This is the picture after the processing and the example result of the number of people living in this area (Left) the input satellite image (Right) the same image after it is processed to classify the area which is a building by the model.

When we use this processing, if the user wants this calculation to cover more area, they need to input more satellite images and also determine the size of that area to the program.

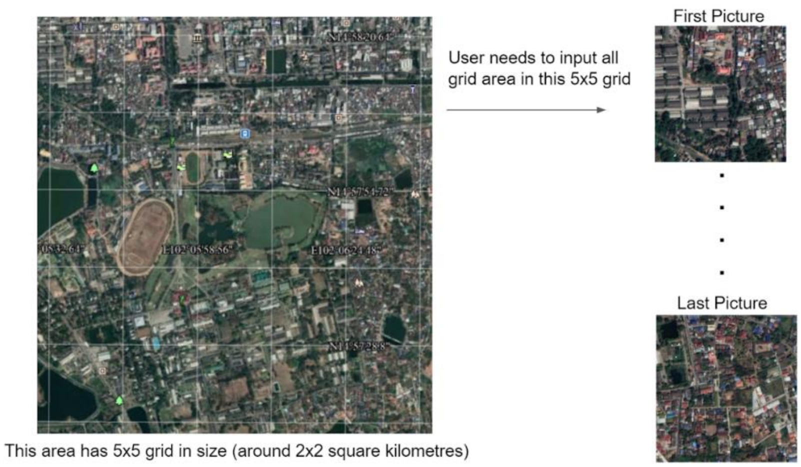


Figure 4. Users need to input all the satellite images which have 1 grid in size, in the area they are considering.

Then, the program will do the image processing and calculation to change the satellite image area into the Matrix which will have entries to be the number of people living in each grid area. Moreover, for now, we assume the number of disaster kits for one person requires 1 kit, in one kit the users should follow the components of the disaster kit instruction [3,4,5]. As the picture below

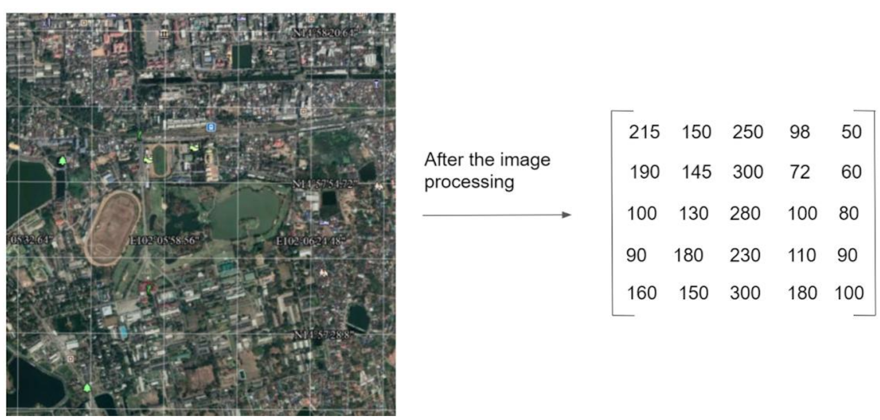


Figure 5. The example results after all of the image processing.

Next step is to find the optimal area. The idea is changing the number of people living in each grid area to mass and finding the center of mass. To find the center of mass, we put the number in each grid to cartesian coordinates and each point will have (x,y) coordinate and its mass(m). The (x',y') of center point can find from $x'=m_ix_i/m_i$, $y'=m_iy_i/m_i$ where m_i is the mass of point i, x_i is the x-coordinate of point i, and y_i is the x-coordinate of point i.

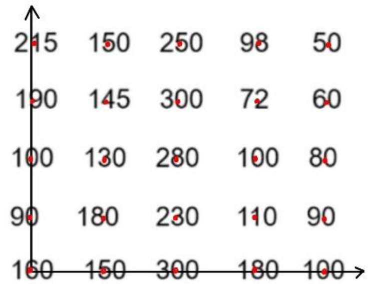


Figure 6. The example of the coordinate determination in our matrix.

And the distance between adjacent points in vertical and horizontal is 400 meters. Center of mass can weigh the number of people, like weight mass. So, it is the best point for distribution. For example, in the picture below, we chose one area like the picture. Then, separate the grid of that picture. After that, find the number of people living in each grid. Lastly, calculating the center of mass; and that is the best point for distribution.

If we have to place many centers, first, we will do the image histogram by using the frequency to be the number of people living in each row. Then, we will separate each area by picking up the row which has the cumulative frequency equal to all frequencies divided by the number of centers that user input. As the example in the picture below, we assume that user have the potential to place 3 centers. So, we divided the area into 3 areas. Then we separate these 3 areas by the row that have cumulative frequency equal to all frequency divided by 3.

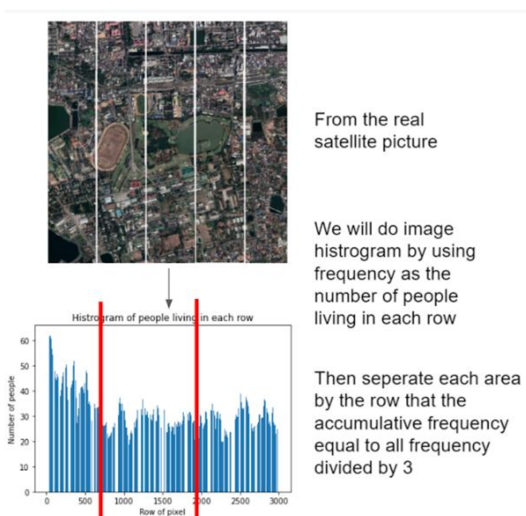


Figure 7. The example of the solution for the problem which users need more than one center.

Then, we will use the same process to calculate the center of mass in each area. The result would be the centers with their best position in each sub-area.

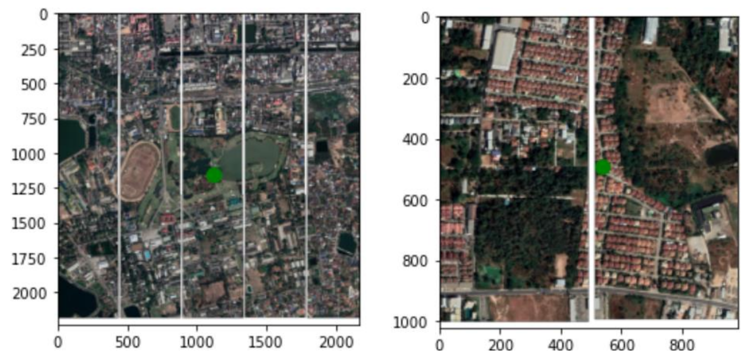


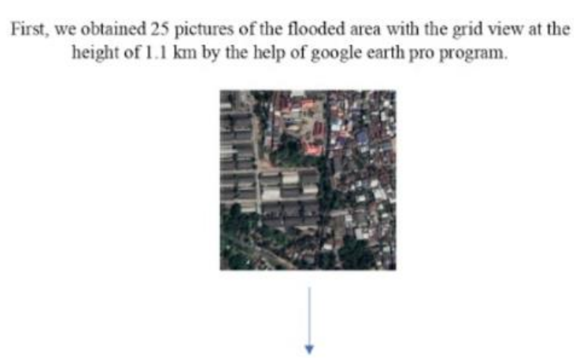
Figure 8. The example of the results after all of the image processing and finding the optimal position. (Left) the area with a 5x5 grid (around 2x2 square meters). (Right) the area with 2x2 grid (around 800x800 square meters) The green circle in both pictures is the best position for establishing the disaster relief center from our processing.

For further development, we can connect the software to the google earth engine and make the user input only the geographical coordinate for processing, this makes the program more user-friendly. To make the model for building detection more accurate, can add more layers to the model in the TFMA process or increase the database with different image sizes (for now this model can only process 300x300 pixels images). For now, our trained model is extremely sensitive to the surroundings, such that a footpath or a garden will be wrongly identified as houses. Thus, if we assume the number of people for each building based on the building area, we need to do more evaluation because the surrounding area that the model can detect might affect the matrix. Moreover, it is possible that even if our building detection model is perfectly fit with high accuracy, the number of people living in the area is not quite as accurate as the model. In this case, we can add the other factors for calculating the number of people, such as the population density in each area, and the slope of the area.

For finding the optimal position, If the center that we calculate is in the water or in the jungle which cannot place it, we have to move to the nearest position that can be placed in the center. Also, the way that is used for helping people could have obstacles that block the way. Thus, the pathway may take a different longer route.

4. Method

The method of this project mainly involves image processing and usage of math models t o find a proper location of relief centers in flooding areas.



Each picture is then cropped to fit the grid and proceed to be sliced by the image slicer into a 300 x 300 pixels image file which will be saved in the specific folder.

We then use python code to calculate the area of objects marked as black (building) and convert it into the total demand of people in the following area.

The area converted will be stored in the form of a matrix corresponding to the original picture before being processed.

$$\begin{bmatrix} 215 & 150 & 250 & 98 & 50 \\ 190 & 145 & 300 & 72 & 60 \\ 100 & 130 & 280 & 100 & 80 \\ 90 & 180 & 230 & 110 & 90 \\ 160 & 150 & 300 & 180 & 100 \end{bmatrix}$$

Each element in the matrix received will be used to calculate the location of the center of mass which will then be mapped into the picture.

5. Innovative Aspect

Our product is specified to help the group of people who are unable to go outside when the flood has already taken place. We aim to locate the optimal position for relief centers that will distribute food to people in the town. Conversely, most other innovations are aiming to help in the evacuation process that may take longer time to accomplish, so our product would become helpful in the first stage before the evacuation is needed or when evacuation is not able to be held. The programmer can also input the number of relief centers they wish to hav e in our model.

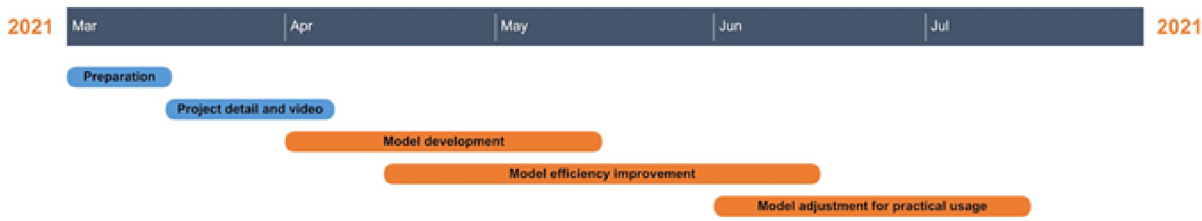
Our software will require the principle of “Center of Mass”. This principle is used to determine the optimal position to create relief centers. Firstly, we will use MachineLearning to detect the households is a certain area, then we will consider 2 factors that include distance from The relief center and the number of people that need disaster kits, determined from the number of households. These 2 variables will be used to determine the center of mass that we will locate a relief center. However, we also generalize for the n relief centers’ cases because we will allow the users to choose, i.e. after detecting and getting the area of households where people live, assi gn it as x. We slowly slide a vertical line to separate the area from left to right, one at a time. Then, we want the first sub-area, which is the one on the left to have the area of households of x/n. Next, we continue to slide another vertical line from the first one and get the sub-area of x/n, and continue doing this until we get n sub-areas that each have the area of x/n. Finally, we locate the center of masses of each sub-area to be the location of relief centers. The idea about Center of Mass is normally applied to analyse each body but not small geographical areas as we are doing, but we see that this can be the fairest way to determine the center point among a certain population. Consequently, this is the innovative part about our work.

6. Applicability

As stated in the project summary, our product is a software that utilizes python programming language to assist in evaluating resource management during a flood. The software will be put up for sales to interested organizations and individuals. Methods of commercialization can be performed by uploading the software onto a website to be able to be accessed by the majority of the people; afterward, if the site gains popularity, we can ask for sponsorship from inverters interested in our product. The risks of this approach are that our users need to possess a level of capability with python programming language to execute the code in the software smoothly, as well as google earth pro, which also requires a certain level of skills to use it. In conclusion, it is not very user friendly to everybody except for people who have experience in coding.

7. Estimated Cost and Project Time Planning

Our project is a software which can be run on a personal computer or portable notebook; it only requires input such as satellite image and some statistics. So, apart from the additional cost of input information such as satellite images which is specifically different in each area (first we have to confirm that satellite image via online open-source platform can be used). And hardware cost which we didn’t sell. Only budget for software value and software operating services are the main cost here. The software operating system we use is google earth pro application and our software uses python coding. Both google earth pro and python can be used via online with no charge too. So, we can assume that this part can be cut off as well. Software developments and server service for our website are the main costs here. We would like to develop websites, including a solution for the main algorithm inside, thus, approximation of our software cost is around 100 USD [6]. This expense will occur in the last part, when we upload our software on the website that requires server services to run on. Apart from that, we count the workforce fee included in those 100 USD costs. From our research about recent competitors, there are only area management software services available for further adaptation. The software can only analyze and present the section of area from satellite images but there is no software or service which specifically focuses on disaster management as our product does.



The picture above is our project calendar, we have developed the model and improved the model to their best efficiency already. And focusing on webpage design and input interface to convenience the users, also, test the model with more types of input to support the usage in extreme areas.

8. Target Audience of the Project Idea (Users):

Damages from flood disasters normally occur as a big region, people in affected areas are the main group to be helped. However, helping processes requires lots of cooperation, resources and human power; one cannot solve the entire problem, so our project cannot directly be proposed to the citizens.

Since these effects are the responsibility of government and disaster management foundations, our project aims to be proposed to those government or voluntary foundations which cooperate with the resource management team in order to improve the efficiency of disaster relief. Government and related foundations can integrate the disaster management procedure with our technology to find the best place for a relief center, find the best way to distribute the resources.

Furthermore, other private businesses that look after huge areas with flood risk are also welcome to use our product. For instance, factories or estates beside huge water sources. Our product can be a good support in disaster relief procedures for the company.

9. Risks

Flaw from user

- The user needs to set up all the libraries required, which is Pillow, Tensorflow, Keras, Opencv-python, Image_slicer.

Flaw from input information

- Do not input the image with resolution less than 300x300 pixels, due to the default setup of our program.
- In the case of urban areas, we calculate from 2D topological satellite images. So, there are errors from disability to distinguish skyscrapers from other buildings.

Flaw from area

- If the center that we calculate from is in water or in a jungle which cannot be placed, we have to move to the nearest position that can place the center.
- The way that is used for helping people could have obstacles that block the way. Thus, the pathway may take a different longer route.

Flaw from program

- The program may take some time to adjust.

- In different areas, the accuracy of the image detection model may vary according to differences in building structure and color in different countries or areas. This risk can be managed by using more specific training images of that country or area.

- There may be some errors which occur because of different version compatibility of python, tensorflow or keras installed in the device which is used to execute the code. This problem should be solved by setting the virtual environment to be python version 3.7 with tensorflow 2.2.0 version and keras version 2.3.1 for executing the program code.

- The program may be less accurate if the images files are not being processed as in the order instructed; following the order provided in the method part will solve this problem.

10. Resources

[1] Scott, M. (2018). *Segmenting buildings in satellite images.* Kaggle. https://www.kaggle.com/kmader/segmenting-buildings-in-satellite-images

[2] *How much living space do you need to be happy?Japan survey results.* (2018, August 5). Real estate Japan. https://resources.realestate.co.jp/living/how-much-living-space-do-you-need-to-be-happy-japan-survey-results/

[3] Said, N. M., Khin, T. A., & Wan Nurizzati, A. (2019). Development of a disaster kit based on a cultural context for flood disaster relief and preparedness. *IIUM Medical Journal Malaysia*, *18*(1), 89–96.

[4] Software developers, Quality assurance analyst, and Testers. (2021, June 9). U.S. Bureau of Labor Statistics. https://www.bls.gov/ooh/computer-and-information-technology/software-developers.htm?fbclid=IwAR0-8WkZeQU7B-74lb7kgRcShv-3CTTmslZNal1X4i9v0ARdzscpIQmKTBc

[5] Bagwell, H. B., Liggin, R., Thompson, T., Lyle, K., Anthony, A., Baltz, M., ... & Kuo, D. Z. (2016). Disaster preparedness in families with children with special health care needs. *Clinical pediatrics*, *55*(11), 1036-1043.

[6] Leonardia, J. A., & Zambrano, P. A. G. (2009). Development of a traditional medicine disaster kit. *Southeast Asian journal of tropical medicine and public health*, *40*, 96.