Humanitarian engineering approach for re-designing pedestrian traffic inside the lecture building during the new normal COVID-19 pandemic

A Yudono1*, Surjono1, C Meidiana1, I Nurika2, E Martati3, S Wibowo4
1Department of Urban and Regional Planning, Brawijaya University, Indonesia
2Department of Agro-Industrial Technology, Brawijaya University, Indonesia
3Department of Agricultural Product Technology, Brawijaya University, Indonesia
4Department of Electrical Engineering, State Polytechnic of Malang, Indonesia

E-mail: adipandang@ub.ac.id

Abstract. COVID-19 has brought a massive impact on people's daily activities, office workers have implemented “Working from Home” (WFH), an elementary school to high school students have implemented “Study from Home” (SFH), as well as Campus academic communities’ activities’ implementing Learning from Home. This circumstance has changed daily human behavior for a year. In 2021, upon the completion of a global vaccination program, the situation is followed by a change in the pattern of daily living activities towards “a new normal”, in which direct human interaction is reinstated while still fulfilling health protocols, one of the actions is social distancing. This study examined the detection of pedestrian traffic for the academic community of the Department of Urban and Regional Planning (DURP), Brawijaya University and predicted certain crowds’ spots in the DURP building, using Computer Vision and the integration of Agent-Based Model and Geographical Information Systems Indoor. Furthermore, alternative designs for pedestrians were carried out in the DURP building to prevent the occurrences of crowds in certain spots. The results obtained are that on the 1st Floor of the DURP building, the West and East entrance paths have high traffic, so it is necessary to arrange for the opening of the Southside door as an alternative for pedestrian access. Likewise, for the 2nd Floor, the opening of the south gate contributes to minimizing crowd spots. All in all, the blended learning process through face-to-face learning at students grades 1 and 2, then online learning at students grades 3 and 4 might minimize the potential Covid-19 transmission facing a new normal higher education learning process.
completion of human life, presenting the gaps between the fields of natural science, widely studied in the STEM clusters and the social science field, widely studied in the SHAPE cluster. Several researchers, including scholars from Warwick University, UK, and academics from Greece, Indonesia, Vietnam and Bangladesh under the ENHANCE project, has developed a curriculum that combines the STEM and SHAPE contexts with Humanitarian Engineering (HE).

The term HE was initially challenging to be found in traditional engineering academic texts. Along with the dynamic of science development, some researchers have attempted to define it. According to Passino [8], humanitarian engineering provides a means to create technologies that help people, while Vandersteen [9] recognised HE as a tool to solve social problems. Hill and Miles [10] affirmed the latest HE studies as solving social problems, addressing sustainability achievement in developing countries. This study investigates complex humanitarian issues from the perspective of the SHAPE scientific family implementing a STEM approach to develop balanced, intelligent and synergistic solutions.

Recently, Modeling and Simulation (M&S) patterns are progressively applied as a powerful instrument to depict the human complex system models, which frequently presents multiple properties such as: development, education, transformation, variety, and positive relationships. With the consistently augmenting accessibility of computing assets, the expanding pool of human computational specialists, and because of its unconstrained materialness across scholastic discipline limits, the significance of M&S has constantly developed at a surprising rate. M&S is generated from academic inter-disciplines from STEM and SHAPE clusters, such as: software engineering, mathematics, research operational, engineering, statistics, and physics, and covers a broad set of application areas like life science, public health, commerce, defense, logistics, manufacturing, supply chains, and transportation [11]. Regular functions of M&S studies contemplate aspects such as: incorporating projections, affectability examination, correlation of control strategy choices, learning and workshop, engineering plan, assessment, prototyping and idea assessment, hazard and wellbeing appraisal, and vulnerability decrease in authorities [12].

Meanwhile, Agent-Based Modelling and Simulation (ABMS) refers to an M&S method for simulating the activities and collaborations of independent agents with the final target to evaluate the consequences for the simulated framework. Having its foundations in examining complex frameworks, complex versatile frameworks, and counterfeit life, ABMS has developed as a characteristic reaction to address the issues of complex frameworks demonstrating [13]. The set-up of models was created by utilizing ABMS, acknowledged as Agent-Based Models (ABMs), featuring applications in different genuine issues; further progressively acknowledged as STEM and SHAPE research problems [14].

In previous years, the two standards of advancement have existed in modelling pedestrian behavior conduct, generated consolidating individual data regarding timetables of tasks to be performed; thereby requiring significant information, obtained through surveys [15]. Second, innovative materials have enabled to gather pedestrian motion information, through cameras, Radio Frequency Identification (RFID), and Global Positioning Systems (GPS) [16,17,18].

This paper thus aims to explore the scientific field of humanitarian engineering by examining the field of planning on a micro-scale through the re-designing of pedestrian traffic inside a lecture building facing a new normal university learning process to prevent the occurrences of crowd spots in anticipating the risk of COVID-19 virus transmission BY using Artificial Intelligent by implementing Computer Vision and the integration of Agent-Based Model (ABM) and Geographical Information Systems (GIS) Indoor.

2. Research method
The study focuses on analyzing the pedestrian motion inside the Department of Urban and Regional Planning building, Brawijaya University and its surrounding area. This research employed descriptive and evaluative analysis of pedestrians, such as Computer Vision, ABM and GIS Indoor. Pedestrian characteristic was analyzed by performing a descriptive statistical method to describe pedestrian movement through flow, speed, and density. Furthermore, evaluative analysis was conducted to assess the density of pedestrian traffic obtained from the peak volume of pedestrians based on time series in each working hour/day.
Computer Vision (CV) refers to a science that applies image processing to generate decisions based on images obtained from sensors [19,20,21]. In other words, CV aims to build an intelligent machine that is able to "see". Meanwhile, ABM is a decentralized and individual-centric approach. When designing an ABM, the modeler identifies the active entity or agent (in this case, the person), defining their behavior, locates agents in a specific environment, establishing connections between them, and running the simulation. Furthermore, GIS Indoor provides a complete mapping system that allows researchers to operationalize the disconnected project data, navigate complex artificial environments, track indoor devices, evaluate space allocation in enclosed spaces, as well as detect and respond to real-time events.

Pedestrian movement is observed and followed, basically addressed as a trajectory [22]. For a given item i that entered the scene at time $t_0$ and left the scene at the time $t_n$, it is expressed as $p_i(t) = \{x_i(t), y_i(t)\} , t_j=0, t_1...t_n$. Upon perceiving that the distinctions $\{t_j+1-t_j\}$ are narrow, the sequence is considered as a continuous function of time $p_i(t) = \{x_i(t), y_i(t)\} , t_0 \leq t \leq t_n$. Every route model comprises an arrangement of N Nodes, in which the fundamental axis of the route and its limits are framed by the arrangement of node positions and bound points systematically.

Through statistical methods, pedestrian motion is assessed through speed, density, and flow. Moreover, an evaluative examination is utilized to examine the pedestrian traffic density collected through peak volume of students and lecturers depending on time series in each weekday hour/day.

$$x = [p \ v_c \ v_{pref}]^T \quad \ldots (1)$$

In detail, p is the pedestrian's spots, $v_c$ is his/her present speed/velocity, and $v_{pref}$ is the selected velocity on a 2D image. A pedestrian's present velocity $v_c$ will in general be not the same as the ideal speed (the selected/prefer velocity $v_{pref}$) that he/she would take without separating from other walkers or obstructions in the scene to accomplish his/her middle objective. The association of the conditions of the relative multitude of other walkers and the current places of the hindrances in the scene denotes the present status of the climate signified by image S. The condition of the crowd, which comprises of individual pedestrians, indicates an association of the arrangement of every common's state $x_i$ union $x_1...x_n$ that sequel i means the ith pedestrian/walker. In this case, the researchers do not expressly demonstrate or catch pairwise connections between pedestrians. Nonetheless, the distinction between $v_{pref}$ and $v_c$ provides limited information about the local connections between the walker and surrounding the environment [23].

Pedestrians are detected by using numerous computer vision methods. One example of a classical method for human detection was proposed by Voila-Jones using Haar-like features [24]. Voila-Jones algorithm, which detects human faces, offers a fast detection rate but in the cost of low accuracy. Moreover, the accuracy drops further bellow for non-frontal faces [2,25].

A better classical method for human detection has been generated with the Histogram of Oriented Gradient (HOG). The accuracy of Injunction with linear Support Vector Machine (SVM) in this method reaches 89% [3,26]. However, the HOG algorithm requires to calculation histogram of gradient orientation which is computationally expensive [27].

With the rapid development of neural network algorithms, numerous modern CV human detection methods have been developed based on this artificial intelligence; AI-based human detection methods include: Single Shot Detection (SSD) [28], Faster Region-based Convolutional Neural Network (Faster R-CNN) [29], and You Only Look Once (YOLO) [30]. Moreover, in contrast with classical image processing methods, AI-based human detection tends to be more robust and reliable [31]. The algorithm for detecting pedestrians in this study utilized the You Only Look Once (YOLO) method. This algorithm was selected due to its reliability while sustaining a fast detection rate [32]. Moreover, YOLO had been demonstrated to outperform HOG-SVM; hence utilized for numerous applications, including autonomous cars [33].

YOLO employs an artificial neural network (ANN) approach to detect objects in an image, dividing the image into regions and predicts each bounding and probability box for each region. These bounding boxes are further compared with each predicted probability. YOLO has several advantages compared to a classifier-oriented system, depicted from the entire image when performing the test with predictions.
that are informed globally on the image. It also makes predictions by synthesizing this neural network, unlike the Region Convolutional Neural Network (R-CNN) system, which requires thousands for an image, making YOLO several times faster than R-CNN.

ABM refers to a commonly entity direction, rule-situated, discrete-event, stochastic, and frequently spatially express model for dynamic modelling and simulations [34,35,36]. ABMs are progressively employed to address and examine the diversified scale complex frameworks, generating applications for various real issues.

An ABM comprises a compilation of autonomous dynamic elements called agents [37]. The agents may then execute suitable behavior for the framework. In addition, ABMs have intrinsic capacities to catch significant demonstrating perspectives like geometry, structure, and space, which simultaneously assist the capacity of modelers to convey, perform, and assess their hypotheses.

As forecasting instruments, ABMs can assist with recognizing the fitting arrangement of existing and new mediations that will probably be synergistic and when they can be sent to accomplish the best outcomes. Since ABMs are generally Personal Computer (PC) based reenactments, they are just approximations of the real world; nonetheless, they give a profoundly refine and organized method of combining data, testing thoughts, or investigating bits of knowledge.

The three significant parts of an ABM include agents, environment, and rules [38]. Agents refer to individual or aggregate substances (such as associations or gatherings). Every agent addresses a player in the artificial (virtual) environments they associate with different agents. By considering a compilation of rules, agents can separately evaluate the condition and decide their way. All in all, the arrangement of agents, environment, and rules, with their characterized limits, intake, and product, makes the framework out of the ABM [11].

In an ABM, the agents' conduct is displayed by decisions that define how agents act because of changes in the environment and toward the arrangement of agent targets. Likewise, these rules characterized a compilation of agent connections: every relationship oversees how every agent communicates with and is associated with, different agents and their current circumstances [11].

Assistance with spatial data and geographic visualization data in ABM becomes a way the model created can represent actual conditions in the field, such as pedestrian traffic and other geographic data. Various GIS and ABM integration applications have been applied in many ways at the macro scale, such as urban and regional areas. Hartmann and Zerjav [39] state that the integration of ABM and GIS has been effectively used in optimizing health service location planning for the characteristics of the urban population. GIS and ABM have been widely applied in building simulation models to develop an area's population, burden and spread of disease, health infrastructure and estimating the impact from resource investment decisions regarding health costs. However, the study of ABM and GIS Indoor integration for microscale such as lecture buildings remains limited. This study was conducted by incorporating CV for data collection rather than for data observation by performing questionnaires or interviews in order to address this gap.

3. Result and discussion

3.1. Dataset Development

Collecting datasets was the first step before YOLO was taught to recognize objects that must be detected. The data collection was accomplished through a video record further transferred into an image. Figure 1 indicate how the data source in the form of a video is retrieved and employed as the first step for training YOLO before labelling the images, by retrieving the video data sources in the video management tools application.
Data processing testing experiments were conducted with the following criteria:

- Raspberry Pi 3
- Mobile Video Camera
- The video was in the .mp4 format
- The recorded conditions total 30 videos.
- The video resolution used was 320x240 pixels with a frame rate of ± 20 frames/second.
- Videos were recorded in a stationary state (static).
- The recording time of each video was ± 10 seconds.
- The video recorded is taken in several conditions such as indoors, dark light (night), outdoors or lots of light and with different background conditions or backgrounds.

The camera used in this study was a camera with VGA resolution that records video using the Open Camera application. The camera settings used were static exposure value conditions. Exposure value is adjusted to the camera's sensitivity to light entering the video recording. The video criteria used in this study were conducted through video with VGA resolution, of 320x240 pixels with bright light conditions during the day outside the room, indoors, and during dark conditions or the indoor lights were off. The video recording has a duration of ± 10 seconds with the condition of several pedestrians walking 5 meters from the camera. The resulting video has a frame rate of ± 20 frames/second. The video used was a video format, collected through various conditions as data training for computer analysis purposes. The reason for recording in different conditions was to navigate how lighting affects the detection results, video conditions in the form of taking videos indoors, outdoors, windy, low light, and other objects other than human disturbances such as shadows, further examined at a later stage.

3.2. Human Object Detection Process

Human object selection was conducted by highlighting the size of each object through blob analysis on MATLAB. The blob analysis function in MATLAB aims to determine the area of a human object using the maximum blob area and the minimum blob area. The step was conducted by eliminating with less than 10000 pixels and larger than 980 pixels. This aims to eliminate non-human objects in the video.

The required process in this study is divided into several stages of the process, comprising: extraction of video frames, image normalization, background subtraction, morphological operations, detection. All stages of the process are related to one another. The initial process is the extraction of the video frame.
to process all the images on the videos. Afterwards, the image is normalized for each extracted frame, further applying the background subtraction method and morphological operations, involving an image reconstruction process in the form of opening, closing, and filling operations. At each stage out of the operations, certain values would also be determined, detected from the human object. The stage details of the process are as follows:

a) Preprocessing. At this stage, video recording and video conversion from the camera are performed by using the Open Camera software on the Android operating system and video conversion from Xillisoft Video Converter. Upon the completion of the conversion in the video cutting, progressed with the video frame extraction.

b) Extraction of video frames. Extraction of video frames becomes one of the processes in computer vision to extract the images (frames) in the video in order to progress the following process. In Matlab, the extraction process is conducted by performing the readFrame () syntax.

c) Image Normalisation. At this stage, the extracted frame image normalization is conducted in a binary image.

d) Background Subtraction. Prior to further process, the initial process (preprocessing) is initially performed through image processing, to get a more superficial image, including converting the image to grayscale. In the background subtraction first, the moving-colored image is converted into a grey or grayscale image converted into a binary image. Then, the initial frame that has no moving objects from the moving image converted into a binary image would be cleaned from the noise to produce a stable background that is sensitive to foreground changes.

After the previous process, the background subtraction operation stage is conducted for the training frame value to determine the static background on the video. Further, the minimum value of the threshold ratio is performed to determine the sensitivity level of binary image changes in background pixels. The training frame value is set at 50. Furthermore, the minimum value for the background ratio is 0.5, in which lower ratio value leads to more sensitive binary image changes to background pixels, and vice versa.

e) Operation Morphology. At this stage, the operations include: opening, closing and filling operations.

- Opening Operation. Opening operations are performed to remove small and thin objects, break objects into thin points, and generally smooth the boundaries of large objects without significantly changing the object area.
- Closing operation. Closing operations are performed to fill small gaps in objects, combining adjacent objects, in order to smooth the boundaries of large objects without changing the area of the object significantly.
- Filling Operations. Filling operations are conducted to smooth the two processes previously accomplished by filling in the gap area to obtain a more solid segment.

After the normalization phase has been completed the human object will be detected. The steps include eliminating objects that are less than 10000 pixels wide, which are more significant than 980 pixels wide to eliminate non-human objects in the video.

f) Preprocessing testing. This stage was regarded as the final stage, where a number of tests were performed at this stage to obtain several threshold values for the next stage. The preprocessing stage was required to detect and calculate human objects at the final stage based on the analysis carried out at this stage. The test was carried out on three videos that represent light, dark, and indoor conditions.

The test results, the threshold value using the range value 0.3 to 0.6, concluded that the practical threshold value for object extraction was 0.5. In each video with different light intensity, the minimum ratio value can detect pedestrian objects well because pedestrian objects look more solid than other values. Furthermore, at a value of 0.3, the object looks solid, but the noise was too high. Furthermore, the minimum ratio value of 0.5 and 0.6 could eliminate noise, but the solidity of pedestrian objects decreases. In conclusion, the minimum ratio value was 0.5, which was effective for extracting objects. The test on the opening operation applies a value ranging from 3x3 to 6x6. The greater the value of the element structure in the opening operation, the more it will affect the eliminated pedestrian. Therefore,
to avoid the eliminated object by the opening operation, the smallest element structure value is determined from the threshold set for the opening operation, which is 3x3.

Testing on closing operations employs a value ranging from 10x10 to 18x18. The greater the value of the element structure in the closing operation, the more solid the object will be. Thus, to anticipate the object disconnection, the value of the most prominent element structure from the predetermined range is selected, which is 18x18.

g) Black-Box testing. From the tests that have been carried out on each button and process on the human object detection system with background subtraction and Morphological Operation, that the following conclusions are as follows:

- The process on the system can be executed correctly starting from precondition until the action is carried out, the system issues output according to the instructions carried out.
- There is a balance between the system functions implemented with the results of the needs analysis determined at the system analysis stage.

The results obtained from the test results on the 30 videos were in the form of "correct" and "incorrect" information. The test was deemed appropriate if the detection results from the system were similar to the manual calculation results. Conversely, if the detection results from the system were different from the results of manual calculations, the information results were thus incorrect. The result indicating that 11 objects were correct out of 30 video records are illustrated in Table 1.

Table 1. Human Object and Trajectory Detection Testing

| No | Name of Picture File              | Number of Objects | Information |
|----|----------------------------------|-------------------|-------------|
|    |                                  | Program | Manual |              |
| 1  | Human and trajectory 1.mp4       | 15      | 15     | Correct     |
| 2  | Human and trajectory 2.mp4       | 10      | 8      | Incorrect   |
| 3  | Human and trajectory 3.mp4       | 12      | 10     | Incorrect   |
| 4  | Human and trajectory 4.mp4       | 7       | 7      | Correct     |
| 5  | Human and trajectory 5.mp4       | 9       | 9      | Correct     |
| 6  | Human and trajectory 6.mp4       | 8       | 8      | Correct     |
| 7  | Human and trajectory 7.mp4       | 14      | 14     | Correct     |
| 8  | Human and trajectory 8.mp4       | 11      | 11     | Correct     |
| 9  | Human and trajectory 9.mp4       | 6       | 6      | Correct     |
| 10 | Human and trajectory 10.mp4      | 5       | 5      | Correct     |
| 11 | Human and trajectory 11.mp4      | 15      | 11     | Incorrect   |
| 12 | Human and trajectory 12.mp4      | 10      | 9      | Incorrect   |
| 13 | Human and trajectory 13.mp4      | 12      | 10     | Incorrect   |
| 14 | Human and trajectory 14.mp4      | 7       | 5      | Incorrect   |
| 15 | Human and trajectory 15.mp4      | 9       | 6      | Incorrect   |
| 16 | Human and trajectory 16.mp4      | 8       | 8      | Correct     |
| 17 | Human and trajectory 17.mp4      | 14      | 12     | Incorrect   |
| 18 | Human and trajectory 18.mp4      | 11      | 7      | Incorrect   |
| 19 | Human and trajectory 19.mp4      | 6       | 6      | Correct     |
| 20 | Human and trajectory 20.mp4      | 5       | 4      | Incorrect   |
| 21 | Human and trajectory 21.mp4      | 15      | 5      | Incorrect   |
| 22 | Human and trajectory 22.mp4      | 10      | 4      | Incorrect   |
| 23 | Human and trajectory 23.mp4      | 12      | 3      | Incorrect   |
| 24 | Human and trajectory 24.mp4      | 7       | 1      | Incorrect   |
| 25 | Human and trajectory 25.mp4      | 9       | 2      | Incorrect   |
| 26 | Human and trajectory 26.mp4      | 8       | 2      | Incorrect   |
| 27 | Human and trajectory 27.mp4      | 14      | 5      | Incorrect   |
| 28 | Human and trajectory 28.mp4      | 11      | 4      | Incorrect   |
| 29 | Human and trajectory 29.mp4      | 6       | 1      | Incorrect   |
| 30 | Human and trajectory 30.mp4      | 5       | 5      | Correct     |

Table 1 presents the ten video tests in bright lighting, in which the eight videos according to manual calculations were correct and the two other videos were not correct. Of the ten video tests in low light conditions, two videos were correct by following per under manual calculations, eight videos were
incorrect. Of the ten video tests in dark conditions, one video was by following per under manual calculation, nine videos were not correct. The tests indicated that the system could appropriately detect pedestrian objects in bright lighting conditions. Meanwhile, at low lighting condition and dark conditions results, less good detection is seen from the number of detections that were not accurate compared to manual calculations caused by distracting shadows on the video forming an object that was counted as a human, especially in low lighting condition videos. In addition to the bias of light on video, other moving objects were apparent such as smoke and shadows of pedestrians. In dark conditions, the camera sensor also affects the detection results due to poor lighting, an unstable camera sensor that makes the detection incorrect and even exceeds the manual calculation. Therefore, during video images data collection for this research, all lecture building areas were set up under bright conditions. Video footage of pedestrian object detection is illustrated in Figure 2 as follows.

![Figure 2. Video recording of pedestrian number and trajectory on the 1st and 2nd Floor of the DURP Building](image)

3.3. Agent Based Model and Geographical Information Systems Indoor Integration Process
Agent-Based Model (ABM) refers to a computational technique that reinforces the investigation of imitation world/artificial environment utilized by agents interfacing in nontrivial ways. Every agent in the response is separately demonstrated, not altogether. Agents who act with agents and respond to their current circumstances change as a set of attitude rules derived from the fundamental theory actions and connections in a specific framework [40].

By correspond topological connections and geographic coordinates, agent attitude is authorized by conducting communication to GIS, sending a "seek to migration" message to the GIS. At that point, the GIS reacts with agent migrating as it updates (and hence renew the GIS database and related graphical demonstration) or returns a message to the agent concerning why the migration could not be performed (for instance, the area is as now involved, or the development is not permitted) [41].

The initial interpretation of the model developed in data processing was conducted by developing the ABM method, described by using logic blocks that function to command agents to move in a predetermined layout based geospacial. The model simulation process was performed by using AnyLogic Software 8.5.2 PLE. AnyLogic incorporates a graphical modelling language and permits the client to expand reproduction models with Javacode. The Java type of AnyLogic fits the custom model expansions by developing Java coding just as Java applets, opened with any standard program. AnyLogic models can be founded on any of the fundamental simulation modelling standards, such as: Discrete-Events (DE), System Dynamic (SD), and ABM. For this case, the researchers merely used ABM.

Anylogic comprises the pedestrian library for simulation to replicate pedestrian routes in a "physical" climate into the computer. It permits users to make models of pedestrian escalated structures (such as metro stations, security posts and so forth) or roads (enormous quantities of walkers). Models support insights mathematics on pedestrian density in various regions. This guarantees satisfactory execution of
administration focuses with a speculative burden, assesses lengths of stay in explicit regions, and recognizes expected issues with interior geometry – as the impact of adding such many obstructions and different applications. In models made with the Pedestrian Library, walkers move in ceaseless space, responding to various types of deterrents (dividers, various types of regions) just as different walkers. Walkers are simulated as connecting agents with complex actions, yet the AnyLogic Pedestrian Library gives a more significant level interface of walker models in the style of flowcharts.

The next stage was the model was filled with a set of rules that regulate the agent movement process. This process is conducted by creating a logic block that commands the agent to make a move. In addition, making layout based geospatial is also needed to regulate the flow of agent movement. This stage was the stage that will lead to the implementation of model simulation and model analysis. Finally, the model was ready to be analyzed and run the simulation (See Figure 3). To run an ABM simulation, rules are defined by entering the instructions, such as:

- **PedSource**, creates pedestrians. It is typically utilised as a beginning stage of the pedestrian flow. It can create a pedestrian of a custom walker type with a self-assertive stream force.
- **PedGoTo**, leads to pedestrian go to the predefined area. An objective line, a rectangular hub or polygonal node, or a point can characterize the area given directions. The pedestrian needs to arrive at a given point any place of the predefined line or hub. Walkers discover a way to the predefined objective inside a current level.
- **PedSink**, deals with arriving pedestrians. It is typically utilized as a terminal or an endpoint of the pedestrian flow.
- **PedEscalator**, corresponds to how walkers are moved by elevator or stairs. The escalator or stairs itself are drawn graphically with the particular space markup shape elevator or stairs meet. Escalators or stairs typically move walkers to a different floor.

![Figure 3. A set of ABM rules in Anylogic](image)

The pedestrian traffic simulation inside the DURP building was run with a time series model for 12 hours of operationalization of teaching activities on weekdays particularly at 07.30 am – 07.30 pm. The simulation was run by setting pedestrian behavior scenarios that included velocity, density and flow correlated with the number of classes, students, lecturers and staff who crossed inside the building.
4. Discussion

4.1. Existing Study of Pedestrian Traffic at the 1st Floor of the DURP Building Under Normal Conditions

Object detection was performed through CCTV recording, which was then processed with CV in obtaining tracking analysis, indicating that the pedestrian traffic on the 1st Floor of the DURP building was located in the corridor connecting the East Gate and the West Gate of the DURP Building with the value of pedestrian density indicated a significantly high category (1.5). Meanwhile, the lowest level of pedestrian density was navigated on the rotation path of the DURP building from the north to the south, continued to the west towards the Faculty of Engineering Administration building with density values ranging from 0.1 - 0.25 (See Figure 4). Existing pedestrians typically select this pathway as the most preferred path in this analysis as several intersections connected other possible directions.

Furthermore, for the Plaza area and North-South corridor in the DURP building, the pedestrian traffic conditions were relatively dense for UB's academic community. This circumstance occurred because this path connected the main rooms on the 1st Floor of the DURP Building. The indication of pedestrian traffic in the DURP building demonstrated the number of active students, in four grades (2020-grade 1, 2019-grade 2, 2018-grade 3, 2017-grade 4) under the six classes of 2020 and 2019 followed by 2018 and 2017 with the four classes. If the average number of students per class is 30 people, then the number of movements in a day in the DURP Building is around 600. This situation has the potential for direct contact, proliferating the COVID-19 virus transmission.

![Existing condition and re-design of pedestrian traffic on 1st Floor of the DURP Building](image)

Figure 4. The existing condition and re-design of pedestrian traffic on 1st Floor of the DURP Building

4.2. Re-designing Pedestrian Traffic at the 1st Floor of the DURP Building for Minimizing Crowd Spots

Upon studying the existing conditions of the pedestrian traffic in the DURP Building for identifying the level of pedestrian density along the building corridors, the researchers further conducted various scenarios in mitigating intense physical contact by opening the South Gate of the DURP Building with restrictions on the movement of the academic community around 360 movements from previously 600 movements. In other words, offline lecture classes are conducted for students under grade 1 (2020) and grade 2 (2019). Meanwhile, students under grade 3 (2018) and grade 4 (2017) would conduct an online learning activity. The study results on integrating ABM and GIS Indoor indicate a significant decrease in the number of movements in the DURP building (See Figure 4). Therefore, reducing the number of movements in the DURP building will help minimize the impact of the Covid-19 virus transmission.

4.3. Existing Study of Pedestrian Traffic at the 2nd Floor of the DURP Building Under Normal Conditions

The electability level of pedestrian traffic with the highest magnitude to be traversed as part of the travel route is worth 1.5, while the lowest level is 0.15, which means that the pedestrian path was not the preferred path to be traversed in one route. Based on the experiment conducted by observing pedestrians...
using the object detection camera previously described, included in the ABM study, the highest level of electability is indicated in the stairway and plaza in front of the DURP library stairs (Figure 5).

The stairway and plaza in front of the stairs and the URP library were selected by the existing pedestrian as the most preferred route in this analysis because all room in the 2nd Floor building has no classrooms, but it consisted of lecturer’ rooms, academics’ meeting rooms, library. Thus, students’ movement in large numbers did not exist through the North-South corridor area in the DURP building. Therefore, the big movement tended to indicate significant movement where the students generally continued the movement to the 3rd Floor, occupied by most classrooms and computer laboratory.

4.4. Re-designing Pedestrian Traffic at the 2nd Floor of the DURP Building for Minimizing Crowd Spots

Re-designing pedestrian traffic on the 2nd Floor of the DURP Building, along with applying the restrictions on the movement of the academic community and the opening of the South gate indicates that there is a significant decrease in the number of movements in the staircase corridor and plaza on the north side of the DURP Building (See Figure 5). As previously explained, the DURP Building on the 2nd floor has no care found in the staircase corridors. Furthermore, the movement activity is divided in the staircase corridor on the North and Southside of the DURP Building. Therefore, reducing the number of movements in the DURP building will help minimize the impact of the COVID-19 virus transmission.

5. Conclusion

Humanitarian Engineering has been regarded as a relatively novel scientific field to fill the gap in the scientific field between the STEM and SHAPE clusters. Furthermore, Humanitarian Engineering examines humanitarian issues and trends that are widely studied in social science in SHAPE cluster with engineering completion as a blend of science from Natural Science and Formal Science in STEM cluster. The Humanitarian Engineering approach in this paper examined the latest social issues related to the COVID-19 pandemic. Upon the completion of global vaccination, human life activities, such as work, school and shopping are expected to normally run as before the pandemic. However, since the studies related to the impact of global vaccination have not depicted optimal results, the prediction of human life activities is conducted by utilizing the 'new normal' method while adhering to health protocols, one of which is to avoid crowd spots in one location.

This result of this study indicated that the Humanitarian Engineering approach studied the pedestrian traffic behavior patterns in the lecture building by using CV, further simulated by using an ABM and GIS indoor. Furthermore, this study proves the result to avoid crowds; on the 1st Floor of the DURP building and on the West and East entrance paths with traffic high. Thus, it is pivotal to arrange the South gate opening as an alternative for pedestrian accessibility. Likewise, for the 2nd Floor, the opening of the South gate contributes to minimizing crowd spots.

Furthermore, students conducting the face-to-face learning process particularly the students of the class under grade 1 (The year 2020) and grade 2 (The year 2019), attracted further empirical studies and on-field case studies. Whereas online learning is implemented for students under grade 3 (The year
2018) and grade 4 (The year 2017), considering that they have relatively few classes, and the learning patterns of senior students are more on critical thinking by increasing exploration of literature studies outside the classroom circumstances.

6. Acknowledgement
This study was conducted through developing Humanitarian Engineering Curriculum under ENHANCE Project, funded by Erasmus+ with partners from Warwick University (UK), University of West Attica (Greece), Universitas Brawijaya (Indonesia), Institut Teknologi Bandung (Indonesia), Universitas Gadjah Mada (Indonesia), Bangladesh University of Engineering and Technology (Bangladesh), University of Dhaka (Bangladesh), Ho Chi Minh City University of Transport (Vietnam), and Ho Chi Minh City University of Technology (Vietnam). Furthermore, this research combined with Universitas Brawijaya’s research under the Faculty of Engineering, Universitas Brawijaya’s non-tax revenue (PNPB) research scheme. Therefore, at the end of this writing, the researchers would say thank you to Erasmus+ and Faculty of Engineering - Universitas Brawijaya.

References
[1] Lagemaat, Richard van de 2006 Theory of Knowledge for the IB Diploma (Cambridge: Cambridge University Press)
[2] Popper, Karl R 1959 The Logic of Scientific Discovery (New York: Routledge Classics)
[3] Davide C 2015 Nature Magazine “Is String Theory science?” Scientific American
[4] Cohen, Elier 2021 The boundary lens: theorising academic activity The University and its Boundaries: Thriving or Serving in the 21st Century (New York: Routledge)
[5] Hallinen, Judit 2015 STEM Education Curriculum
[6] British Academy 2020 SHAPE
[7] Black J 2020 SHAPE – A Focus on the Human World Social Science Space
[8] Passino K M 2015 Humanitarian Engineering: Creating Technologies That Help People (Bede Publishing, Ohio)
[9] VanderSteen J D J 2009 Humanitarian engineering in the engineering curriculum ProQuest Information & Learning
[10] Hill S, Miles E 2012 What do students understand by the term 'Humanitarian Engineering'? International Conference on Innovation, Practice and Research in Engineering Education
[11] S J E Taylor 2014 Introducing Agent-based Modeling and Simulation (Palgrave Macmillan)
[12] L. G. Birta and G. Arbez. Modelling and Simulation. Springer, 2007.
[13] Arifin S M Niaz, Maday G R, Collins F H 2016 Spatial Agent-Based Simulation Modeling in Public Health: Design, Implementation, and Applications for Malaria Epidemiology
[14] D A Luke, K A Stamatakis 2012 Annual Review of Public Health
[15] Ali W, Moulin B 2006 How artificial intelligent agents do shopping in a virtual mall: A ‘believable’ and ‘usable’ multiagent-based simulation of customers’ shopping behavior in a mall. Canadian AI L, Lamontagne, M Marchand (Eds) (Berlin: Springer-Verlag) pp. 73–85
[16] Teknomo K 2002 Microscopic pedestrian flow characteristics: Development of an image processing data collection and simulation model (Graduate School of Information Sciences, Tohoku University)
[17] Tanaka H, Shibasaki R 2005 3-D spatial behaviours or urban lives, a smart mobile mapping and visualizing system the 10th International Conference on Computers in Urban Planning and Urban Management (London)
[18] Shoval N, Isaacson M 2006 Application of tracking technologies in the study of pedestrian spatial behavior The Professional Geographer 58 172–183
[19] Shapiro LG, Stockman G C 2001 Computer Vision (Prentice Hall)
[20] Forsyth D A, Ponce J 2011 Computer Vision: A Modern Approach (Pearson Education)
[21] Szeliski R 2011 Computer Vision: Algorithms and Applications (Springer)
[22] Ming X, Tim E 2001 Object Detection and Tracking in an Open and Dynamic World 2nd IEEE International Workshop on Performance Evaluation of Tracking and Surveillance (Hawaii, USA)

[23] Bera A, Randhavane T, Prinja R, Manocha D 2017 SocioSense: Robot Navigation Amongst Pedestrians with Social and Psychological Constraints

[24] P Viola, M Jones 2001 Robust Real-Time Object Detection

[25] T Shan, B C Lovell, S Chen 2006 Face Recognition Robust to Head Pose from One Sample Image 18th Int. Conf. Pattern Recognit.

[26] N Dalal, B Triggs 2005 Histograms of oriented gradients for human detection 2005 IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit.

[27] J Rettkowski, A Boutros, D Göhringer 2017 HW/sw co-design of the hog algorithm on a xilinx zynq soc J. Parallel Distrib. Comput. 109

[28] W Liu, D Anguelov, D Erhan, C Szegedy, S Reed, C Y Fu, A C Berg 2016 SSD: Single Shot MultiBox Detector BT - Computer Vision – ECCV (Springer International Publishing)

[29] S Ren, K He, R B Girshick, J Sun 2015 Faster {r-cnn.:} towards real-time object detection with region proposal networks

[30] J Redmon, S Divvala, R Girshick, A Farhadi 2016 You Only Look Once: Unified, Real-Time Object Detection 2016 IEEE Conf. Comput. Vis. Pattern Recognit.

[31] A Uçar, Y Demir, C Güzeliş 2017 Object recognition and detection with deep learning for autonomous driving applications Simulation 93(9) 759–769

[32] S Srivastava, A V Divekar, C Anilkumar, I Naik, V Kulkarni, V Pattabiraman 2021 Comparative analysis of deep learning image detection algorithms J. Big Data 8(1) 66

[33] M Al-Nuaimi, S Wibowo, H Qu, J Aitken, S Veres 2021 Hybrid verification technique for decision-making of self-driving vehicles J. Sens. Actuator Networks 10(3)

[34] S J E Taylor, A Khan, K L Morse, A Tolk, L Yilmaz, J Zander 2013 Grand challenges on the theory of modeling and simulation Proceedings of the Symposium on Theory of Modeling &Simulation - DEVS Integrative M&S Symposium (San Diego, CA)

[35] S M N Arifin, R C Kennedy, K E Lane, A Fuentes, H Hollocher, G R Madey 2010 P-SAM: a post-simulation analysis module for agent-based models Summer Computer Simulation Conference (SCSC), July 2010.

[36] M Batty 2003 Agent based pedestrian modelling Advanced Spatial Analysis: The CASA Book of GIS P A Longley, M Batty (ESRI Press: Redlands)

[37] E Bonabeau 2002 Proceedings of the National Academy of Sciences of the United States of America

[38] J M Epstein, R LAxtell 1996 Growing Artificial Societies: Social Science from the Bottom Up (Complex Adaptive Systems) (The MIT Press)

[39] Hartmann T, Zerjav V 2014 Optimizing the Location of Out-Care Centers in Urban Space Using Agent-Based Modeling (Construction Research Congress)

[40] Macal C M, North M J 2005 Tutorial on Agent-Based Modelling and Simulation Proceedings of the 2005 Winter Simulation Conference Euhl M E, Steiger N M, Armstrong F B, Joines J A (eds.)

[41] Brown D G, Riolo R, Robinson D T, North M, Rand W 2005 Spatial Process and Data Models: Toward Integration of Agent-Based Models and GIS Journal of Geographical Systems, Special Issue on Space-Time Information Systems 7(1) 25–47