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FRAMEWORK ON 4IR TECHNOLOGY IN SOLVING CRIME SCENE INVESTIGATION

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Abstract

In Malaysia, crime scene forensics animations are becoming an increasingly important visual aid in courtroom situations, where complex data relating to a sequence of events is being visualized before a general public who may have little or no understanding of established forensic procedure or methodology. This paper will introduce and discuss a spectrum of new technology that utilizes new developments in the Crime Scene Investigation. The paper will be utilized on introducing five different frameworks that would be needed in order to implement 4IR technology with the Crime Scene Investigation. Crime Scene Investigation is a method of protecting, processing, and reconstructing a particular crime. It is a process of preserving the evidence, running tests on the preserved evidence, and constructing possible scenes that could picture the crime. The process includes a framework that is used as a guideline on what needed to be followed to get all evidence to be accepted in the court room. In this paper, the frameworks are developed with from the past frameworks. This is where the discussion of the objective is made. This will allow the users to understand how to implement the 4IR Technologies in the Crime Scene Investigation.

Keywords: Crime scene investigation, Digital evidence, Image mapping, Unmanned aerial vehicle (UAV), Virtual reality (VR).

1. Introduction

We are living in a world which is surrounded by advanced technology. The technology field has stretched in many directions not only in the field of information technology, but involving in the field of medical, transportation, finance and the most recent unmanned aerial vehicles and virtual reality. With the development of advanced technology such unmanned aerial vehicles and virtual reality has become a common thing that people adapt to in their daily work. Unmanned aerial vehicles have become more affordable, their popularity with the general public and commercial organizations has seen significant growth in recent years according to Horsman [1]. Unmanned aerial vehicles or drones are now devices for hobbyists and aircraft-enthusiast to enjoy. Not to forget also virtual reality, according to [2-5]. Virtual reality will become even more accessible within everyday jobs with people using it for medical training, new building designs, training and learning and other experiences. Virtual reality will see an increase of usage especially within training and learning settings.

The paper introduces and explores a variety of emerging developments, which use the latest technology of Artificial intelligence (AI), unmanned aerial vehicle (UAV), virtual reality (VR), and industrial revolution 2.0. This paper deals with prior research inside the investigative framework of the crime scene. The restoration of the crime scene is a way of capturing, storing, and repairing the crime scene. This is a method to protect the evidence, analyses the evidence and establish the future crime scene. The procedure provides a mechanism to guide what needs to be done in order to receive all proof accepted in the courtroom. This paper would help with the basic purpose of journals with planning. This helps users to consider the basic purpose of using the 4IR technologies in a crime scene investigation.

2. Unmanned Aerial Vehicle (UAV) Framework

Unmanned aerial vehicles (UAV) are used in different fields, including civil, military, commercial and government applications according to Lagkas et al. [6]. We have surveillance and delivery applications in military and governmental areas primarily to obtain and provide information at locations following a disaster or attack and to distribute medicine or another essential medicine items. Commercial applications focus on the delivery of goods and products in urban and rural areas. UAVs are considered because they depend on sensors, antennas, and embedded software. During the investigation into the crime scene, the investigator faces many problems due to the complex nature of the crime scene areas. For instance, if a hilly region is a crime, evidence and secondary crime scene can extend to the lower hill areas and it is highly important to barricade, document, photograph and videotape such criminal scenes and difficult at the same time.

According to Mishra et al. [7], an investigator must also take a look at the crime scene showing the evidence positions and searching and collecting evidence without manipulation. Any type of contamination is possible. the evidence value is lost, and the scope of research is narrowed. The management and investigation of the crime scene is time. Consuming and involves a large number of trained staff and experts. Hence, the technology of UAV has not be used to help investigation of crime scene. With the advance technology of UAV in the market. We came out with a framework to use UAV technology in a crime scene as shown in Fig. 1. In

the chapter an explanation will be made on the framework that is developed and how to use the framework to map a crime scene.

Step 1, **Hazard identification**. Hazard identification is a section where UAV operates is required to identify all hazards. for instance, The weather, windspeed of the surrounding, terrain or obstacles in the area, etc. The operator is also required to determine the level of airspace restriction on the particular crime scene.

Step 2, **UAV Initialization Check**. UAV Initialization check is the most crucial step in the framework. Where the UAV operator teams is required to check initial condition of the UAV before taking off for a mission. The procedure is usually based on a checklist to determine the condition of the battery, remote controller, camera gimbal, motor/rotor blades if is cracked or defect, the compass calibration of the UAV, GPS signal strength, etc. This is a mandatory step that every operator must follow.

Step 3, **UAV Pre Flight Check**. Pre-flight check is the final inception on the UAV before taking off. The procedure is also usually based on a checklist which is comprised of the readiness of the UAV, operator and also the spotter. The spotter is in charge and responsible for the look, movement, and feel of the footage during a flight airtime. Before taking off the UAV operation team is required to follow and complete the checklist. The checklist measurement consists of aircraft orientation, navigation battery and radio communication test, position of destinated crew, etc. This is a crucial step where it will determine the success of the mission.

Step 4, UAV **Pre Landing Check**. Pre-landing check is to determine the landing of the UAV. For instance, the landing point of the aircraft, the landing gears, to check grounds cape for any possible incursion, to check the battery status if emergency landing is executed. This measurement taken Is also based on a pre-set checklist to ensure if any emergency occur the aircraft will be able to land safely on the ground.

Step 5, **Autonomous or Remotely Piloted UAV Takes Off**. This is a section in the framework where the UAV operator will initiate take off. the take-off of the UAV can be executed in two different ways. manually controlled by the operator itself or autonomous via UAV console application. For instance, by simply tapping on “Fly”, confirm and take off.

Step 6, **Execute Mission Plan**. The execute mission plan is linked to image mapping framework. where once the mission plan is upload to the UAV the drone will automatically take off and complete the survey based on the selected scope. Once the survey is completed, or your device is running out of power the application will make your UAV come back to the starting point or land right where it is.

Step 7, **Flight Log**. This is the section where the flight log is created and recorded. The UAV operator team is required to log the flight information manually to be more precise. The flight log report must consist of flight Type, ID, date of mission, overall duration, location, purpose of flight, etc. All the information gathered must be recorded properly for future post-mortem and review. However, with the help of the UAV operating application, all the signification information of the aircraft during the mission will be recorded automatically. The flight logs created with values of all parameters will be uploaded to UAV operator controller once the mission is concluded.

Step 8, **UAV Post Flight Check**. Post flight check is finally stage of UAV framework where The UAV operator team is required to finalize the condition of the UAV after a mission .to be more precise the person in charge is required to check the condition of the drone to ensure that it is in a good condition .the inspection but include the condition of the UAV, remote controller, battery status ,airframe, rotor blades and also the data gathered to be verify.

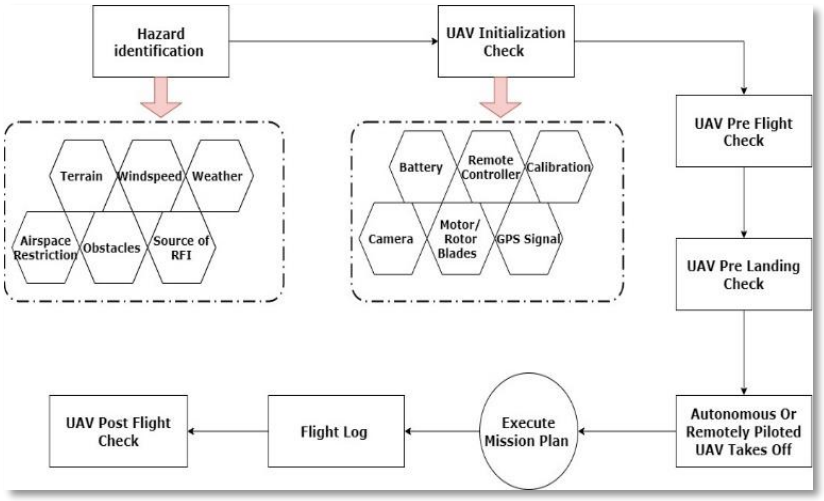

Fig. 1. The framework for UAV

3. Image Mapping Framework

Crime scene steps such as documentary photography, videotaping, evidence search, and reconstruction can be done with a drone. According to Mishra et al. [7], A drone can help the investigator directly from the laboratory as an important tool in tele forensics. For example, a fingerprint found on the crime scene can be pictured and sent directly through the drone to the fingerprint recognition office. The scanned image can be analysed, and results obtained at the crime scene in no time. The incorporation of a drone into image mapping can therefore enable the investigation process and save time.

Merging UAV technology and image mapping together will allow the evidence to be admissible in the court room as less human error will occur. A framework will be needed to educate the users on the process of integrating UAV and image mapping software to ease the process of capturing a crime. In the chapter an explanation will be made on the framework that is developed and how to use the framework to map a crime scene. Fig. 2 shows the framework that is developed to map a crime scene in crime scene investigation.

Step 1, **Selecting your drone mapping ecosystem**. Once your UAV is it's time to choose a "mapping solution" The app will help to plan your flight properly, and it will take over the control of the UAV operating application to automatically complete the mission or crime scene. Once the mission is complete, we will need to move your data from your UAV to a computer after the flight. You need to extract the micro-SD card from your drone, attach it to a computer and upload the captured data to an image processing software, so the data is processed, and the

final output is displayed and analysed. The processing tools are orthomosaic, which are essentially stitched together areal images from your drone, transformed to be chart metric, as well as 3D models and point clouds. This work by taking images of the same object from at least two perspectives, you will get a stereoscopic 3D view. That is why the images from your drone must significantly overlap. The best overlap is 70/80.

Step 2, **Planning your flight, Mission**. The main concern when flying a UAV should be safety. For mapping mission, whether areas with or without trees and high structures we should be caution and not fly in restricted area or above people. When planning a mission, we should consider all possible consequences. for instance, when a crime scene occurs, we are required to analyse the area and the surrounding. Hence, all information regarding the mission should be sent on the mapping software. Information such as, Area, altitude, overlap of photo taken, speed of UAV, maximum flight time, terrain, or obstacles of surrounding ,3D or 2D and also connection of UAV during flight is signification for an accurate mapping.

One of the most important parameters is the altitude of the flight. The lower the altitude, the more images the drone must take to survey chosen area, the longer it will take to complete the survey and the more time and resource consuming the data processing. The altitude will also influence a pixel size according to Buczkowski [8]. Example in Fig. 3 is a mapping software (Map Pilot) configuration before departure. It takes 20 to 30 minutes for the application to complete its image capturing. This duration would differ as the size of the location would define the time taken for the image capturing process.

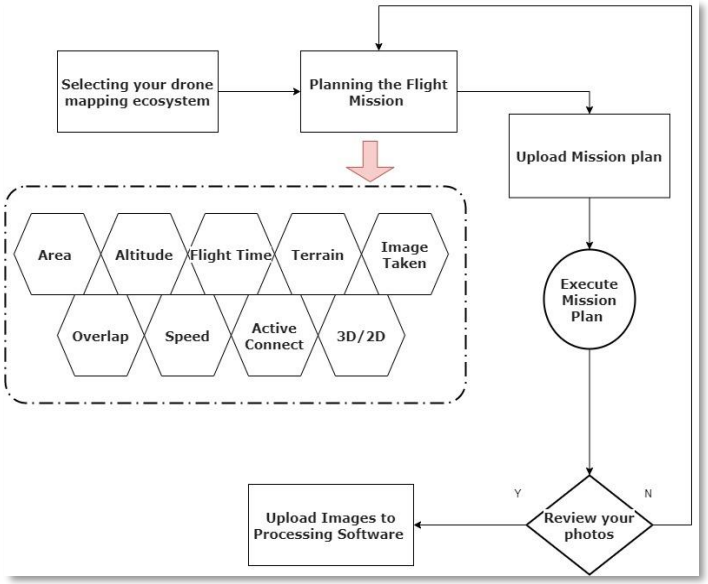

Fig. 2. The framework for image mapping/processing.

Fig. 3. Mapping software (MAP Pilot).

Step 3, Upload mission plan. Once the mission plan is ready, finalize and approved by the person in charge the plan will be uploaded to the UAV/Drone to be prepared for departure. Uploading the plan to the mapping software should be thoroughly verify with other members including the chief of operation and the spotter to ensure that everything set is according to plan. The spotter also my ensure that the flight path is correct and no obstruction along the path. In the case of an obstacle detected, the reconfiguration of the flight planning or path should be evaluated once again. if everything is set and verify, you can upload the mission plan to the drone.

Step 4, **Execute Mission Plan**. Once the mission plan is successfully uploaded to the UAV or Drone. The UAV operator team will depart the aircraft from the home point. Now the drone will automatically fly and complete the survey or mission based on the selected scope. Once the survey is completed, or in the case of the device is running out of power the app will navigate the UAV home to the original location or the starting point and land it. Once the new battery is exchanged the mapping software will automatically take control of the drone by taking it off and continue the mission as per schedule, starting on where it left off.

Step 5, **Review the photos**. Once the mission is concluded, extract the SD card, and review all the images taken before uploading to image processing software. If any irrelevant images are found or blur photo taken. We are required to review the "**Planning the flight Mission"** for any error in configuration and repeat the process from there. According to Buczkowski [8] in some case pictures of the sky or taken at a strange angle might negatively influence the final effect of the Orth mosaic and 3D model. Hence, if you are satisfied with all the pictures taken, sort out images from the flight for process by copying them into a separate folder.

Step 6, **Upload Images to Processing Software**. Now it is time to upload the data into the image processing software. The software will stitch all the photo taken together and the output will be depending to the picture taken during the image mapping .it could flat areal image of the mapped area called "orthomosaic" or a 3D point. This progress will take hours depending on the number of photos taken. the

more photos, the more time it will take to snitch every image. As shown in Fig. 4 is an example of image processing software. The duration to analyses and stich the images that is capture would be different from other case. This is due to the size of the area. The bigger the area, the longer the analysis and image stitching would take. Besides that, the resolution of the final output does play a vital role in the time taken.

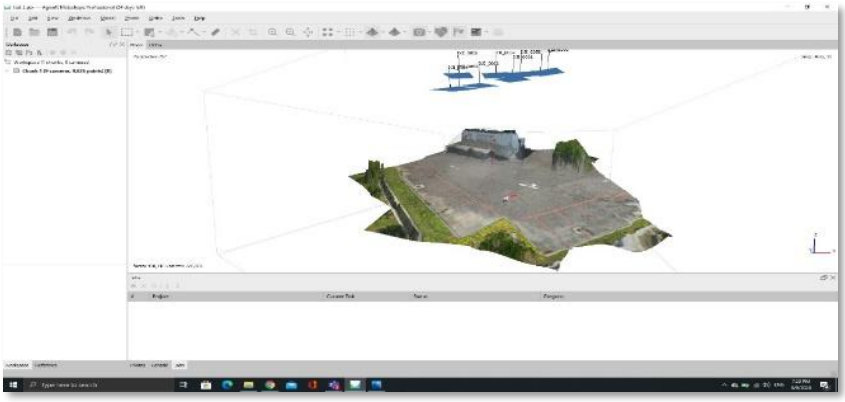

Fig. 4. Image processing software.

4. Virtual Reality (VR) Framework

Out there in the internet world there are hundreds of virtual engines that could be used to develop the simulation, but it can be said that of the hundreds of virtual engines the unreal engine could be most recommended to be used. This could be due to the option which is given to the users whereby they can modify codes without accessing the internal of the engine. This would make the amendment process to be easier and faster. There are a few more virtual engines which can be recommended such as Quake Engine, LithTech Engine and Delta3D Engine.

In order to obtain or implement virtual reality in the crime scene investigation a framework needs to be introduced in order to allow users to preview on how to make use the virtual reality. In the chapter an explanation will be made on the framework that is developed and how to use the framework in order to have virtual reality in the crime scene. Figure 5 shows the framework that is developed and designed to have virtual reality in the crime scene investigation.

The process of having virtual reality in crime scene would begin with **configuration for proceeding**. This means, the files related to the process are being loaded for the process to begin. Virtual engine plays an important role in getting the header files. These header files would allow the users to call out some functions that would be used in the process [9]. Mainly the header files contain all types of data that would be more useful. At the same time, the virtual engine will declare some number of declarations in order to work on the project. For example, the variable would be declared and the shared memory for multiprocessor would be set associated with different type of function, procedures clock and also the state of the engine. Upon declaring and shared memory being brought up, the pipelines would be powered up to set up or bring up a number of internal functions in order to begin the work on the particular mode that is being selected [10].

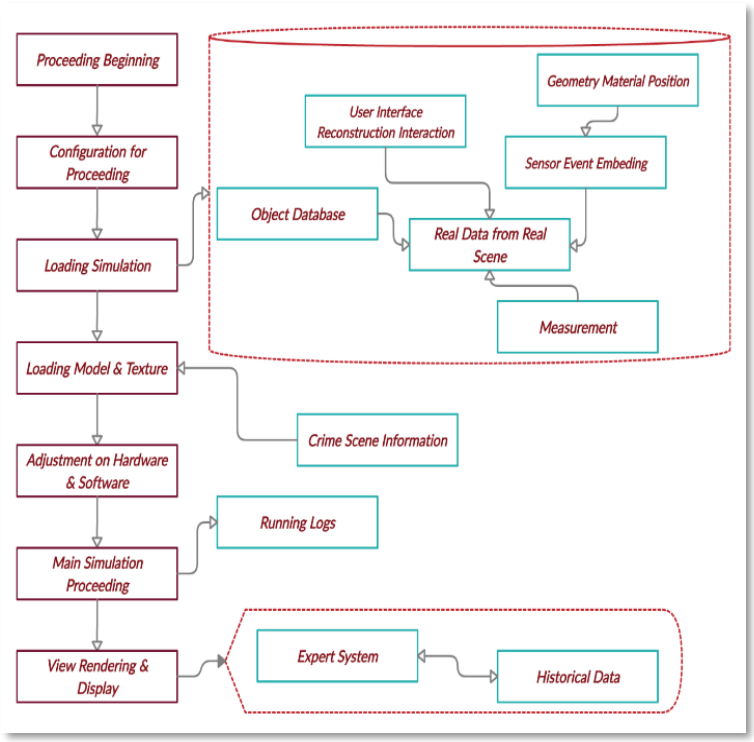

Fig. 5. The virtual reality framework.

It will then move to **loading simulation.** This means, in this stage the users will input all the data files into the virtual engine in order to command the engine to build up a scene. Basically, the user will need to input the data that is related to case, and the engine will load all sort of simulation data and finally it will create the suitable scene with the data collected. This will make things easier as the user does not need to design one by one by, they could just make some small changes. This step basically would ease up the job of the users. At the same time, the virtual engine will also begin to integrate with the database in order to get any similar simulation or simulation that would have more common simulation. By doing this, the development of simulation would not be complicated, and it would be easier to be understandable. In a breakdown of the loading simulation the main factor of this process is database. The engine will compare the database with the real data that has been collected from crime scene such as user interface, measurement and sensor event embedding which is the geometry material position.

Furthermore, **loading model and texture** would be the next process. This stage is where the information of the scene will be fed into the simulation that has been developed. The virtual engine would select certain static model from the library database and then it will add on the texture. This is where the objects would be fed into the simulation. This will get the simulation almost ready. Ready here would be the exact scene where the object will replicate the scene as if it is live from the scene. This will bring the simulation to live, and it will make the simulation to be complete. It can be said, in this stage the simulation is developed completely whereby the objects are fed into the simulation scene.

Then, they will move into the **hardware and software adjustment**. This means, the setting of the graphic, the processor, and the pipeline. By doing this, the simulation would face some sort of reality feelings. In this part of stage is where the surrounding is being set up and this is where on the accuracy of the simulation. This setting would keep the simulation smooth and functional. They will also have a setting on the frame rate to set the aspects ration. Although the simulation is important, these types of settings would play a vital role in keeping the simulation perfect and it also keeps the view suitable to the case.

Next, the **main simulation proceeding**. This means logs are being run and captured. In process information or in other word detailing of the simulation would be amended according to the crime scene and these would also include small detailing on the simulation. By doing this it shall keep the simulation and exact replicate of the crime scene. this step sometimes could be skipped as sometimes this can be done in the loading model and texture.

The process in virtual reality ends with the **view rendering and display**. This means, internal functions would be triggered, and they will deal with the cone image. The results will later be sent to the display in their aspect. As the result is displayed the data will be uploaded into expert system. This happens in order to allow them to store it for future use and it will be sent to the knowledge base which will allow the data to be used in future crime scene investigation. This allows the users not to face any issues in the future as they could use this data to investigate future cases. This is the final step, and this will be recorded in the knowledgebase in order to be used in the future. This knowledgebase would also be used later in the court room and this knowledgebase would also play a role as the expert witness as they would have more simulation.

5. Digital Evidence Framework

Evidence is always important in order to solve a crime case. This is because evidence is used to prove an argument and at the same time, they can be used to refuse any sort of fact in an argument of people to disagree or to hold the fact [11]. Nowadays, the percentage of digital evidence is increasing that makes them more important. This is because, as the internet gets developed the usage of internet or in other word technology has evolved in all activity that makes evidence being captured in digital and therefore the digital evidence is important.

In order to preserve the digital evidence and allow the evidence to be admissible in the court room. A framework will be needed to educate the users on the process of preserving the digital evidence and converting them into admissible evidence. In the chapter an explanation will be made on the framework that is developed and how to use the framework in order to preserve the digital evidence in the crime scene. Figure 6 shows the framework that is developed and designed to have digital evidence in all crime scene investigation.

As we can say, when evidence is discovered the first thing that comes to mind is how to preserve the evidence. As in this case we can say the investigator or related parties will need to decide on how to **preserve the digital scene**. Preserving them properly would allow us to keep the scene secure. This preservation point is where the evidence that is being collected would be kept in a secured location. Storing in a secured location would keep the evidence unharmed by any other act.

This could prevent the evidence from facing any disturbance which would result in a loss of the evidence. In order to gather the evidence, **the Chain of Custody** is important as without having a proper chain of custody the evidence is not admissible in the court room. By doing this, it may protect the evidence and resulting them to be admissible in the court room.

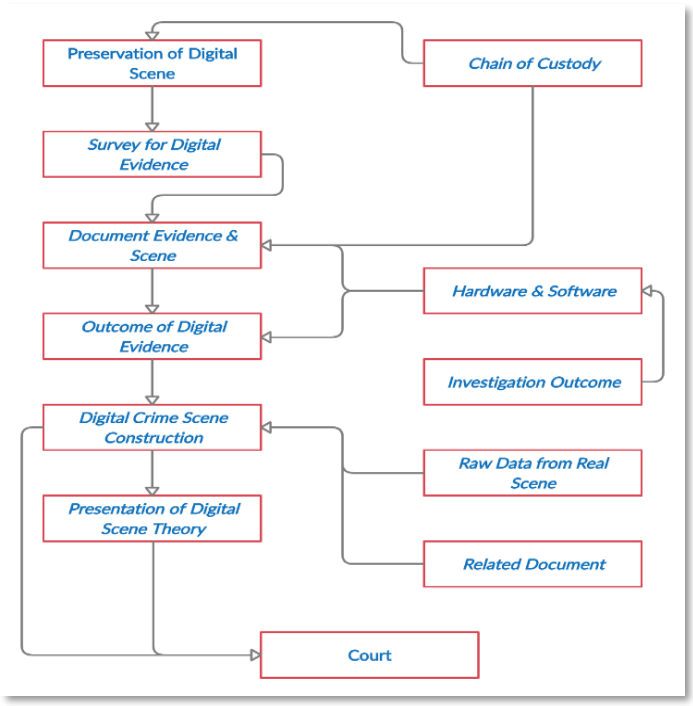

Fig. 6. The digital evidence framework.

Moving on upon collecting and preserving the evidence, the investigator will later **conduct a survey for digital evidence**. This is important as it will allow the investigator to describe and classify the evidence that has been gathered. Classifying the gather evidence would allow the investigator at the later part to decide on how to verify the evidence in a proper manner that would be admissible in the court room. In a simpler form, the investigator could work on the evidence with proper and appropriate tools that would be admissible in the court room.

Then, the investigator will need to **document the evidence and the scene of the crime**. This means the investigator will need to prepare a report for the evidence. The document will also cover the crime scene whereby the simulation will need to include, and the simulation will also need to be set as evidence in order to demonstrate the crime scene. Those days, evidence images of the crime scene that is captured would be used as evidence in the courtroom but with the 4IR technology, simulation would eliminate the images of the crime scene as the simulation would replicate the crime scene. It is recommended that the documentation and simulation will need to be stored in both hardware and software in order to prevent any loss.

Next, **documentation and outcome of the evidence**. Although both of this are separate in the flowchart, but they could be done at the same time as the investigator will need to document the evidence in both the software and hardware of the scene and then they will need to add on the outcome that they have gain from the evidence. By doing this, it may allow them to keep the evidence in a neat manner and this will allow non expertise to understand. It is also advised to store it in hardware and software in order to secure them. The documentation mainly will cover off the outcome and findings in both evidence and simulations. Both of these will later be presented in the courtroom which will be at the end.

Later, **digital crime scene construction**. This is where the raw data and raw logs are being stored. With this data and logs the crime scene will be developed virtually and this will be supported with useful documents. With the help of the logs, data and documents the investigator could construct the Crime Scene. Constructing here refers to the situation of the scene which includes how it took place, why it took place, where it took place and many more.

Finally, **presentation of digital scene theory**. This is where documentation will be done to explain the findings of the investigator. This documentation would be used in the court room as the judges, and prosecutor could use it to learn the whole case without visiting the crime scene as they would use the digital crime scene that is being constructed. In a nutshell, by following this framework there is a high possibility of not missing out on any procedure and the evidence would be admissible in the court room.

6. Crime Scene Investigation (CSI) Framework

Procedure or steps will need to be followed appropriately in order to investigate a crime scene. It is important that the investigator should be well prepared for any sort of investigation in any type of crime scene. This framework begins with the crime scene. When a crime scene takes place there will be three main aspects that would be used. These three aspects play a vital role in the 4IR technology. Upon using them to develop a simulation scene digital evidence would be added into the picture as the outcome will be presented in the court room for justice [12].

In order to begin an investigation or being the first person in the crime scene the respective individual will have to set up the process on how to react to the crime scene. A framework will be needed to educate the users on the process of handling the crime scene. In the chapter an explanation will be made on the framework that is developed and how to use the framework in order to plan out the investigation. Figure 7 shows the framework that is developed and designed for the crime scene investigation on having 4IR in the process.

The use of the framework would begin when there is a crime scene that has taken place. The crime scene in the framework refers to the physical presence of the scene that has taken place. When a crime took place that would be the scene that needed to be transformed into simulation with the help of 4IR technology.

Secondly, UAV (Unmanned Aerial Vehicle). This means, with the help of drone, the images of the crime scene will be taken. The drone will be used to fly around the crime scene in order to capture images of the crime scene which will be used later in the image processing. The drone will fly around the crime scene to capture all possible images.

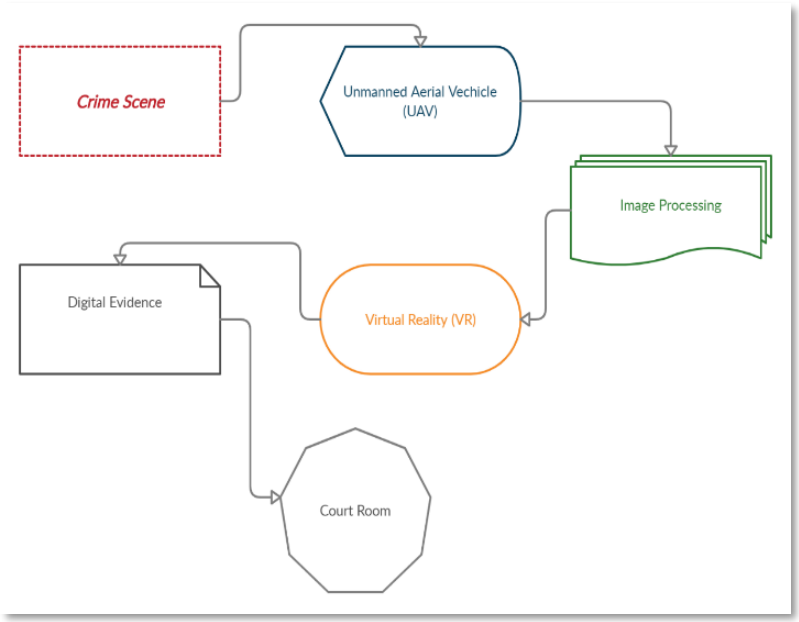

Fig. 7. The crime scene investigation using 4IR technology framework.

Image processing would be the next procedure upon completing the UAV procedure. This means, images will be processed here with the help of AI. The images that are captured from the crime scene using the drone will be used to convert the images. Once the images have been stitched it will then get transferred to virtual reality. This means, the images that is being processed in the image processing will allow the users to develop simulation that will be used in the virtual reality by using the gears.

To settle the whole procedure the final procedure would be digital evidence. This means simulation and will be classified as digital evidence. This digital evidence will be presented in the courtroom. The cost of completing the whole process would depend on the package that is picked by the users. the user would need a drone that has a high-resolution camera. DJI would be a perfect device that would help the investigator with capturing the image. Besides that, the software that is used would also define the cost. The project was completed with PiX4D and Agisoft. Both of the software would sum up to USD 60.00. This would be the cost of the software and the drone would be in the range of USD 500.00 to USD 900.00.

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References

1. Horsman, G. (2016). Unmanned aerial vehicles: A preliminary analysis of forensic challenges. *Digital Investigation*, 16, 1-11.
2. Waugh, B. (2017). The #1rated polling and Q&A platform. Retrieved June 4, 2021, from www.vevox.com.
3. Jeevitha, R. (2021). Virtual crime scene investigation and evidence protection. *Engineering and Scientific International Journal*, 8(3), 92-94.
4. Maynea, R.; and Green, H. (2020). Virtual reality for teaching and learning in crime scene investigation. *Science and Justice*, 60(5), 466-472.
5. St.Edwards University. (2022). About St. Edwards University. Retrieved June 8, 2021, from www.stedwards.edu.
6. Lagkas, T.; Argyriou, V.; Bibi, S.; and Sarigiannidis, P. (2018). UAV IoT framework views and challenges: towards protecting drones as "things". *Sensors*, 18(11).
7. Mishra, V.; Dedhia, H.; and Wavhal, S. (2015). Application of drones in the investigation and management of a crime scene. *Forensic Science*, 4(4).
8. Buczkowski, A. (2017). Retrieved June 8, 2021 from www.geoawesomeness.com.
9. Agisoft Metashape. (2020). Discover intelligent photogrammetry with metashape. Retrieved June 8, 2021, from www.agisoft.com.
10. Sharma, N. (2019). A computer science portal for geeks. Retrieved June 8, 2021, from www.geeksforgeeks.org.
11. Feng, X.; Daguo, S.; and Hongchen, Y. (2010). Simulation research of crime scene based on UDK. *Proceedings of the 2nd International Conference on Information Science and Engineering*. Hangzhou, China, 1-4.
12. Mentor (2020). Mentor. Retrieved June 8, 2021, from www.mentor-adepis.org/.