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A Scheme and App for Converting UAV Project Specifications to Project Design and Implementation

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Abstract
The client's specification (scale, area, contour interval, site location and accuracy) of a UAV project determines the type of UAV to be used, the cost of the project, project duration, ground control needed, flying height, the amount of lateral overlap and side lap to be used for the project. The conversion of the client's requirements to project specification is time-consuming but must be done correctly. Hence, there is a need for automating the process. The aim of this project is to streamline the processes of converting client's requirements into UAV project specification and in turn converting project specification into project design and implementation. The outcome of this research includes a standalone application called UAVPP which was designed in MATLAB programming environment. It converts client's requirements into project specification, costing and design. The UAVPP application will serve as a guide to drone users for project specification costing and design.

Keywords: Client's Specification, Project design and implementation, Project Specification and UAVPP Application

1.0 INTRODUCTION

Before the advent of unmanned aerial vehicle (UAV), aerial photogrammetry was carried out using airplanes or helicopters and metric cameras. It involves various processes information on the heights to which the aircraft soared and the use of expensive metric cameras and series of overlapping photographs along flight lines. UAV offers affordable access to precise aerial mapping (Fraser *et al*., 2015 and Linchant *et al*., 2015).

UAV also known as a drone is any aircraft that does not have a human pilot onboard (Colomina and Molina, 2014). Drone can also be defined as remote-controlled pilot-less aircraft (ICAO, 2011 and Rohizan *et al.*, 2021). UAVs have their origins as early as 1915 when Nikola Tesla wrote a dissertation in which he described "An armed, pilotless aircraft designed to defend the United States (Dempsey, 2010). The most common applications and operations associated with UAVs are stockpile measurements and quarry monitoring (De Goede *et al*., 2016), precision agriculture, infrastructure inspection, forest management, coastal erosion studies and other environmental and archaeological projects (Fernandez and Gutierrez, 2016; Stocker and Karrasch, 2015).

According to Kung *et al*. (2011) the developments of UAVs in recent years along with the improvements in Structure from Motion (SFM) software and computer vision enhanced the production of photogrammetry. Drone survey is increasingly being used for many survey projects (Meouche *et al.,* 2016). It is highly relevant thus making many surveyors, geoscientists and allied professionals choose this approach over other methods of surveying. Unlike conventional surveying method, there is no standard scale of fee and approach to converting client requirements to project specification in UAV projects. This research will thus be of great importance if a scheme could be designed for this conversion. Project costing is highly important for proper, efficient and successful aerial mapping. Application of drone in photogrammetry has been widely accepted due to its efficiency, less time consumption and low personnel cost. It is important to have thorough planning before proceeding with a mapping project. Successful planning requires several meetings with the client to discuss the products, cost, scale, proposed

schedule, and accuracy. A variety of products may be developed in a given photogrammetric project like prints of aerial photos, photo indexes, photomaps, mosaics, orthophotos, planimetric and topographic maps, and digital maps for GIS database (Muhammad, 2019).
Project costing depends on the specification of the end user; the conversion of this client's requirement to project specification is time-consuming and rigorous for the surveyor. Hence, there is a need for automating the process.
UAV project specification (contour interval, scale, site location, accuracy etc.) will determine the type of UAV to be used, the amount to be paid for the project, project duration, number of ground control points, method of orientation (interior, relative, absolute and exterior), flying height, overlap and side-lap to be chosen for the project.
This study entails the understanding of client requirements, details for project specification and details on project design for crop monitoring and topographic mapping. MATLAB application software was used in implementing the design.
The study which is aimed at streamlining the processes of converting clients' requirements into UAV project specification and converting project specification into project design and implementation has as its objectives the development of schemes for converting client's requirements into detailed project specifications for two representative industries.

2.0 MATERIALS AND METHOD

2.1 *UAV Specifications*

Drones selected for this study are based on industrial applications.
Topographic survey: The drones selected for the topographic survey are the preferred and recommended drone for topographic survey, six drones were selected, and their properties are described in Table 1.

Table 1: Properties of Drones selected for Topographic Survey

	DRONE TYPE	FOCAL LENGTH (mm)	IMAGE SIZE (aspect ratio)	SPEED (m/s)	BATTERY LIFE (minutes)
1	DJI Phantom 4 Pro	35mm	5472×3648	10m/s	30 minutes
2	DJI Mavic Pro	35mm	4000×3000	3m/s	30 minutes
3	Autel Robotics X-Star premium	40mm	3840×2160	16m/s	25 minutes
4	Yuneec Typhion H pro	14mm	3840×2160	19.4m/s	25 minutes
5	Mavic Air	24mm	4056×3040	8m/s	21 minutes
6	Phantom 4 RTK	24mm	4864×3648	3m/s	30 Minutes

Agriculture survey: Drones selected for the agriculture survey are the preferred and recommended drone out of the drone available within this region, seven drones are selected, and their properties are described in Table 2.

Table 2: Properties of drone selected for agriculture survey

S/N	DRONE TYPE	FOCAL LENGTH (mm)	IMAGE SIZE (aspect ratio)	SPEED (m/s)	BATTERY LIFE (minutes)
1	DJI Smarter Farming Package	19mm	3840×2160	17m/s	38 minutes
2	DJI Phantom 4	35mm	4000×3000	10m/s	28 minutes
3	Precision Hawk Lencester 5	26mm	4056×3040	22m/s	45 minutes
4	SenseflyeBee SQ	25mm	4864×3648	12m/s	55minutes
5	Mavic Air	24mm	4056×3040	8m/s	21 minutes
6	MdMapper 1000+	35mm	7952×5304	10m/s	45 minutes
7	Phantom 4 RTK	24mm	4864×3648	3m/s	30 minutes

2.2 UAV Project Specification

Project specification is simply the product of converting the client specification into parameters that can be understood by the UAV system. They are derived from the client requirement given (the purpose of the survey, area to be covered and scale). The project specifications are explained below:

(i) Flying height: this is the altitude of the aircraft at the moment of exposure during the flight mission. It can be computed using equation.

$$flying\ height = scale\ \times focal\ lenght \quad (1)$$

(ii) Ground coverage of one frame of imagery: This is the dimension of the scene covered by one photograph, it is given by:

$$Ground\ coverage = photo\ size\ \times scale\ factor \quad (2)$$

(iii) Forward overlap: It is necessary in aerial photography in order to obtain a stereoscopic image. The amount of overlap is usually expressed as the percentage of the ground photo coverage (Imam, 2018). The percentage overlap required depends upon the purpose for which the photography is to be used and will be given in the mission specifications. This ranges from 55% to 65% and 60% is made constant for this research.

(iv) Forward gain: it is the forward distance that the photo coverage advances for each successive photograph along the run.

$$Forward\ gain = ground\ coverage\ \times \frac{(100 - \%forward\ overlap)}{100} \quad (3)$$

(v) Number of photographs per run or strip: the minimum number of photos to be taken along a run of a given length is given by:

(1) Dividing the run length by the forward gain.
(2) Rounding the number up to the next whole integer.
(3) Adding 1 to ensure overlap at the end of the run

As a safety factor, the mission specification will usually call for a few extra photos (often three) at each end of the run.

$$Minimum\ no.photos = \frac{(run\ lenght)}{forward\ gain} + 1 \quad (4)$$

(vi) Sideways overlap: To obtain complete coverage of the survey block, the spacing of the flight lines is arranged so that, there is certain amount of sideways overlap. The amount of sideways overlap is expressed as a percentage of the ground photo coverage. This ranges from 20% to 40% and 30% is made constant for this research.

(vii) Line spacing: the line spacing is given by:

$$Line\ spacing = grid\ coverage\ \times \frac{(100 - \%side\ overlap)}{100} \quad (5)$$

Also, in calculating the number of lines in the project area, it is better to note the width of the project. The minimum number of survey lines is found by dividing the width of the project by the line spacing and rounding up the result to the nearest whole integer.

$$Min\ no.lines = \frac{(area\ width)}{line\ spacing} flight\ lines \quad (6)$$

(viii) Number of photographs: the total number of photos to be taken in a given survey block is found by multiplying the number of photo per run by the number of runs.

$$Total\ number\ of\ photos = minimum\ number\ of\ photos\ \times minimum\ number\ of\ lines \quad (7)$$

Note: when planning for the amount of film to be used, additional allowance must be made for loading the camera, testing, and re-flying runs due to navigation errors.

ix) Time required for the mission:

$$Speed = \frac{distance}{time} \quad (8)$$

Distance between exposures is equals to ground distance covered by each photograph along flight line.

Hence, the required time per exposure

$$Time\ taken\ per\ exposure = \frac{distance\ between\ exposure}{speed\ of\ UAV\ in\ space} \quad (9)$$

Therefore, the total number of times required for the entire mission is given by:

$$Total\ number\ of\ time\ required\ for\ the\ entire\ mission = Total\ number\ of\ exposure\ \times Time\ taken\ per\ exposure \quad (10)$$

Also,

$$Total\ number\ of\ time\ required\ for\ the\ entire\ mission = Total\ number\ of\ photographs\ for\ the\ mission\ \times Time\ taken\ per\ exposure \quad (11)$$

(x) Total number of batteries required: this can be gotten by determining the time required for an entire mission and span of selected UAV for the survey.

$$Total\ number\ of\ batteries\ required = \frac{total\ time\ required\ for\ the\ mission\ (in\ minutes)}{span\ of\ each\ UAV\ batteries\ (in\ minutes)} \quad (12)$$

3.0 RESULTS AND DISCUSSION

3.1 User processing interface

The various interface and pages which include the launch page (start page), the selection stage (selection based on industry either topographic or agriculture survey); computation interface, survey report, launching of Google earth and mapping procedure interface were designed and programmed as shown in the subsequent subsections.

3.1.1 Launch page

The launch page is the first page shown when the application is launched, it is also known as the START PAGE. The launch page consists of the name of the user, FUTMINNA logo, student name and passport, the supervisor's name, and others. The 'proceed' icon will lead the user to the next GUI and it is shown in Figure 1.



Figure 1: Launch page

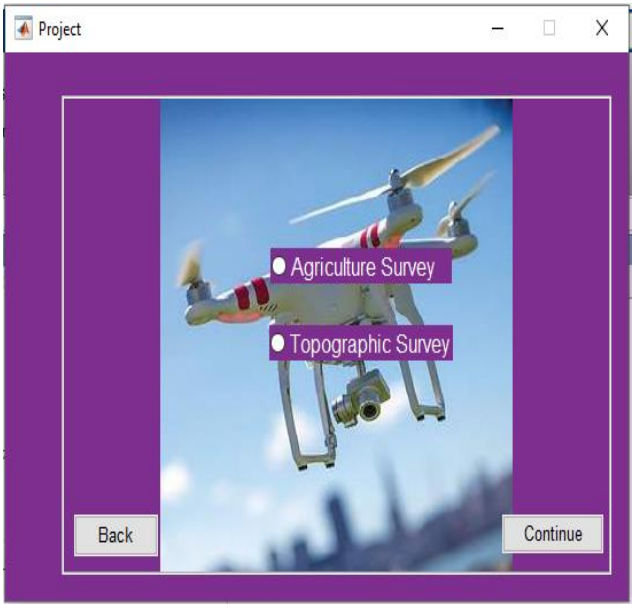


Figure 2: Selection page

3.1.2 Selection stage

This is the second stage on UAVPP. The selection stage is used for selection based on topographic or agriculture survey. This will proceed after selecting to computation interface and the selection page is displayed as shown in Figure 2.

3.2 Computation interface stage

This stage is the basic stage, this performs many tasks like drone selection, input parameter (scale, Area (L×W) and Area (meter square)), result display, Google earth link, mapping procedure and survey report.

(i) Drone selection: This is where the user selects which type of drone to use according to selected industries (each industry has different preferred drone based on their properties). After selecting the drone automatically, the parameters will be displayed like image size, battery life span, speed and focal length. The display selection page is displayed as shown in Figure 3.

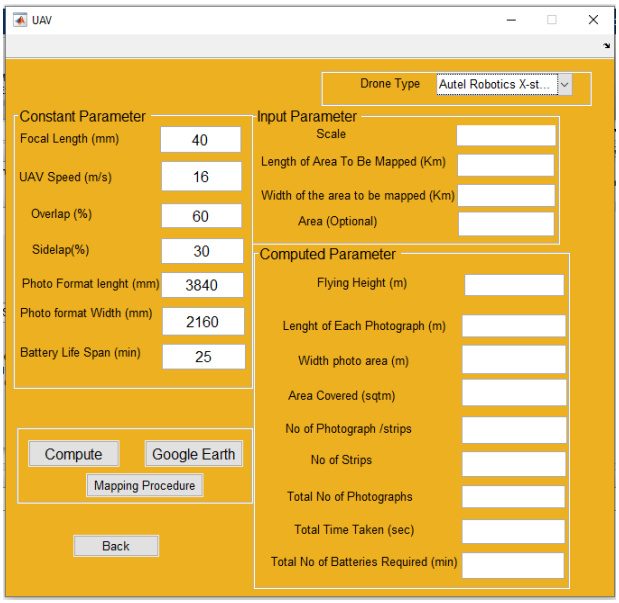


Figure 3: Drone selection



Figure 4: Input parameter

(ii) Input parameter: This is done after the drones have been selected; this section is where the user will input client specification like scale, Area (L×W) and Area (meter square). The input parameter page is displayed as shown in Figure 4.

(iii) Result display: After the parameter has been inputted, the user will click on the "proceeds icon" and the result will be displayed automatically. The result which will be displayed are flying height, number of photographs per strip, overlap and sidelap, the total number of photographs and the total number of batteries required. The result display page is displayed as shown in Figure 5.

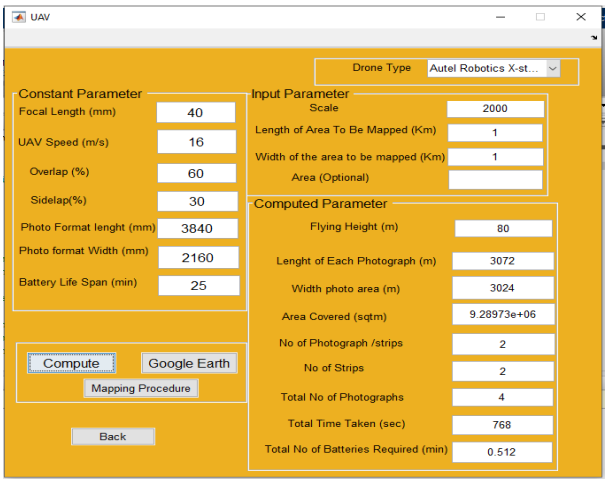


Figure 5: Display result



Figure 6: Google earth link

(iv) Google earth: computation interface has google earth link whereby whenever the user clicks the link, Google earth will open automatically for reconnaissance purposes. Also, an internet connection is needed only in this session. The Google earth page is displayed as shown in Figure 6.

(v) Mapping procedure: The mapping procedure link is used for achieving objective two of this research, which is to develop the skill for converting project specification to project design and implementation. Therefore, when the user clicks the link, it will automatically open Microsoft word on the computer. Microsoft word will display the step-by-step procedure used in carrying out drone mapping with the project specification and also, the document consists of how to process the acquired data (image processing). The mapping procedure page is displayed as shown in Figure 7.

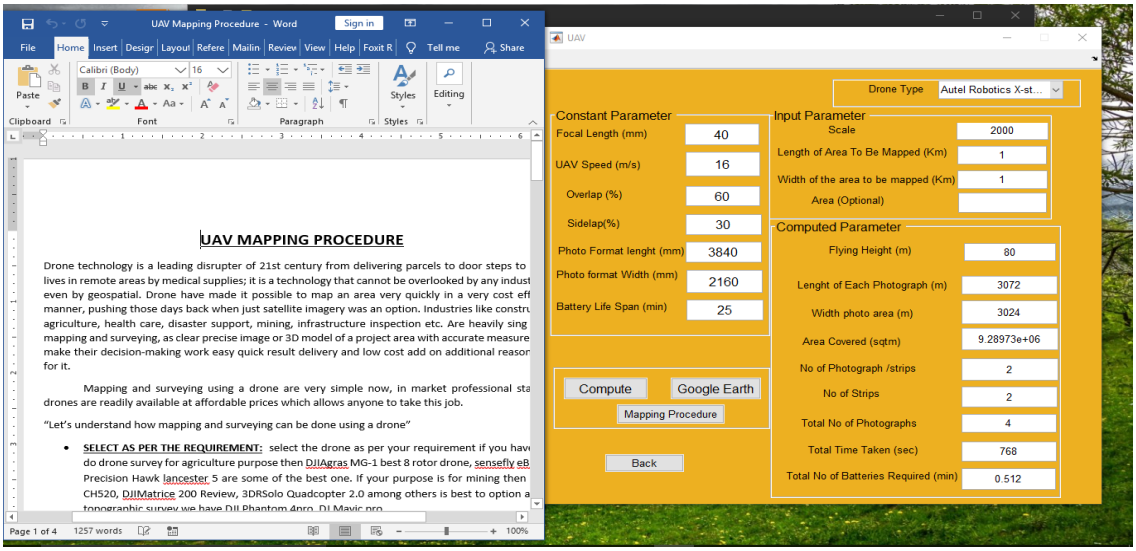


Figure 7: Mapping procedure

(vi) Survey result: After the result is displayed, when the user clicks the "proceed icon", this will automatically open a Microsoft word document and display the result in word document format. The survey result page is displayed as shown in Figure 8.

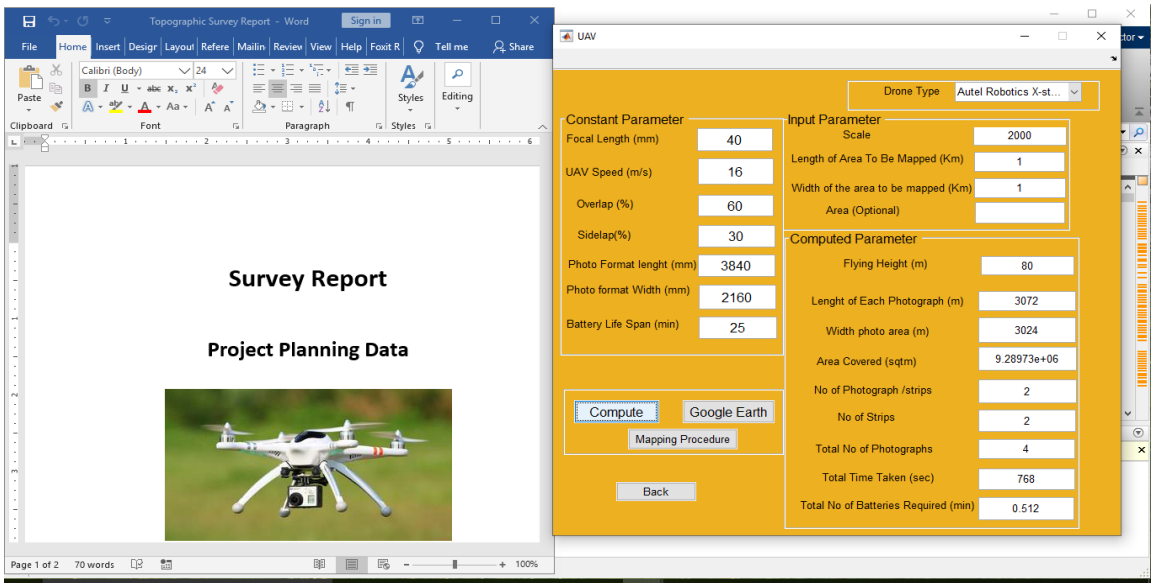


Figure 8: Survey result

3.3 Specification for the APP

The code and GUI are packaged using the application compiler tool in MATLAB environment, to convert it to a standalone desktop application. Figure 9 shows the packaging stage, whereby the main file, the picture for the splash screen and other files required for the application to run has been added and packaged.

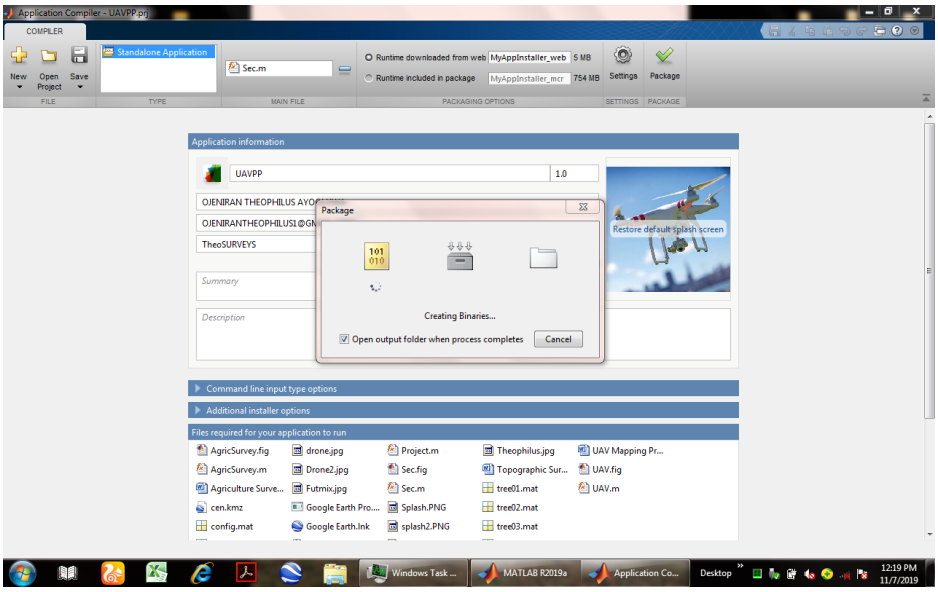


Figure 9: Packaging stage

The properties of the application are described in Table 3.

Table 3: Application specification

Application Properties	Description
Programming Application	MATLAB
Size	5.3mb
Runtime	120s
Operating System	32&64 bit
Application type	System Application

CONCLUSION

This study is geared towards developing a platform for converting client's requirements to field mission parameters in photogrammetry mapping with the use of UAV. The study analyzed the needful parameters and their mathematical formulations needed for any UAV mission specifically for agriculture and topographic surveying. To make the conversion of client specification to project design effective, there is a need to develop a robust system. This research was able to create a system that can convert specifications for agriculture and topographic surveying. UAVPP were developed to convert client specification to project specification and project specification to project design and implementation. Three GUI were designed, the first GUI is the launching page of the application, the second GUI is the selection page and the third GUI contains a drone selection panel, input parameter (scale and area), mapping procedure panel, Google earth panel and display of the result. UAVPP is however different from other applications in terms of operational mode like provision for two means of inputting site dimensions, working without an internet connection, google earth for reconnaissance and mapping procedures.

There are somewhat ineffective or no existing standard parameters for the instrumentation of drone surveys. Although this research was able to identify some parameters, there is still a need to establish generally accepted parameters that will be adopted and be useful for all forms of drone deployment.

RECOMMENDATION

The study recommended that further studies should be done to develop a robust system which will not only allow the use of application for crop Monitoring and topographic mapping only but also support other fields of surveying. There should be establishment of a standard project specification for drone surveying as there was no concrete and valid specification during the time of this research.

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