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3D Mapping Using Aerial Photogrammetry

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ABSTRACT: UAV software now is in the open market and the application of UAV in many sectors has increased. Application of 3D Mapping is widely used in mining, excavation sites, cartography, etc. Generally, LIDAR sensors are used for creating these maps but with the improvement in photogrammetry, it is now possible to use images of these sites to create a close to accurate 3D model. This requireshigh-resolution images taken from different angles for the same object. Capturing images of object is tedious and slow so to speed up the process UAVs can be used for data acquisition i.e., for taking images of the area easily and quickly. This resulting 3D model can be used to calculate physical measurements in a geographic information system.

KEYWORDS:UAV,3D Mapping, Reconstruction, Photogrammetry.

I.INTRODUCTION

The 3D digital model helps us understand topographical knowledge and help the user understand and observe the features of the selected object. Using aerial photogrammetry allows the user, easily data acquisition of large-scale mapping. Obtaining images through drone photography, software reconstruction can help us build a 3d representation of the area of interest which combines concepts of photogrammetry image acquisition, flight planning, and data extraction. Aerial photogrammetry only aims at image analysis and data measurement. One of the methods to get the 3D model is by importing images taken from the UAV and transferring them to the software to complete processing.

II.UAVFLIGHT PLANNING

UAV Flight and data sampling is planned to be usingdedicated software, starting with knowing the region of interest, required ground sample distance or footprint, and intrinsic parameters of the onboard digital camera. The flightaltitude is derived by setting the image length and focal length of the camera. By setting the longitudinal and horizontal overlap of lines we can compute the waypoint. For a 3D model generation, it is necessary to have low GSD and High overlapping. Depending on the mission, type of platform, and environment condition there are flight modes viz. Manual, assisted, and automatic. Automatic modes are usually utilized onboard GNSS/INS for take-off, navigation, landing and to guide image acquisition. The typology of flight has a greatimportance on the image network quality. Image overlap and geometry of acquisition are irregular in manual mode but with GNSS/INS and navigation system acquisition can be assisted and improved. Navigation system viz. Auto-pilot is helpful to plan missions and communicate with platforms.

The Ground home Station is used to observe the platform during flight and to get real-time data such as position, altitude, speed, battery status, speed of rotors, etc. Contrary remote-control systems are controlled by an operator at the ground station. Quality and reliability are related to the electronics: low-cost devices are useful for missions with low altitude and low flight times, while expensive devices are useful for covering a wider area for a long time. Overlaps in images are affected by wind, sensor quality, and operators' experience.

III.PHOTOGRAMMETRY PIPELINE

After getting the images the following steps are defined in the photogrammetry pipeline

A. Natural Feature Extraction

The aim of this step is getting distinctive teams of pixels that are, to some extent, invariant to dynamical camera viewpoints throughout image acquisition. Hence, a feature within the scene ought to have similar feature descriptions to all told pictures. The most well-known feature detection methodology is that the SIFT (Scale-invariant feature transform) formula. The initial goal of SIFT is to extract discriminative patches during an initial image which will be

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compared to discriminative patches of a second image regardless of rotation, translation, and scale. As a relevant detail solely exists at a precise scale, the extracted patches are focused at stable points of interest. The key plan is that, to some extent, one will use the SIFT variables to affect the image transformations occurring once the viewpoints are dynamical throughout image acquisition.

B. Image Matching

The objective of this part is to seek out pictures that are looking to an equivalent area of the scene. For that, we tend to use image retrieval techniques to seek out pictures that share some content without resolving the resolution of all features matches in detail. The ambition is to alter the image in a very compact image descriptor that permits the space between all picture descriptors with efficiency. One of the foremost common techniques to get this image descriptor is the vocabulary tree approach. Passing all extracted options descriptors into it makes classification by scrutiny their descriptors to the ones on every node of this tree. Every feature descriptor finally ends up in one leaf, which might be held on by an easy index: the index of this leaf within the tree. The image descriptor is then diagrammatic by this assortment of used leaf indices. It is currently attainable to check if totally different pictures share equivalent content by the scrutiny of these image descriptions.

C. Texturing

The objective of this part is to seek out pictures that are looking to an equivalent area of the scene. For that, we tend to use image retrieval techniques to seek out pictures that share some content without resolving the resolution of all features matches in detail. The ambition is to alter the image in a very compact image descriptor that permits the space between all picture descriptors with efficiency. One of the foremost common techniques to get this image descriptor is the vocabulary tree approach. Passing all extracted options descriptors into it makes classification by scrutiny their descriptors to the ones on every node of this tree. Every feature descriptor finally ends up in one leaf, which might be held on by an easy index: the index of this leaf within the tree. The image descriptor is then diagrammatic by this assortment of used leaf indices. It is currently attainable to check if totally different pictures share equivalent content by the scrutiny of these image descriptions.

IV. 3D MAPPING USING PHOTOGRAMMETRY

IV.I Component Selection for Drone:

Multirotor thrust Chain

The drive system provides the thrust to the vehicle and consists of the propeller, the motor, an ESC to control the motor, and a battery to power the motor.

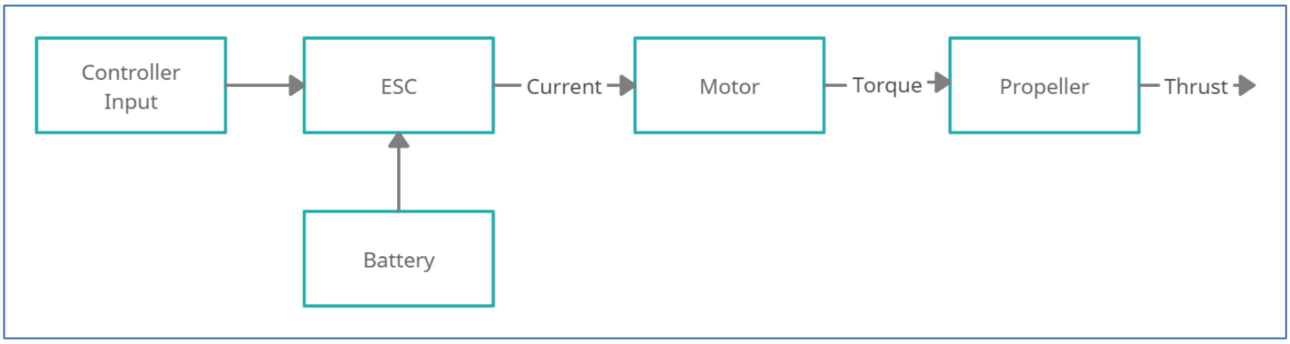

Figure 1Multirotor Thrust Chain

1. Frame

We will be using a standard drone frame configuration X and dimension of 45 cm; the frame model is f450.
Selected Frame: f450

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2. Motor

In a UAV motor's function is to drive the propeller. After thrust calculation, selected compatible motor with the frame model, which is the A2212 series BLDC motors, considering the thrust factor per motor we selected A2212 1400 KV motor.

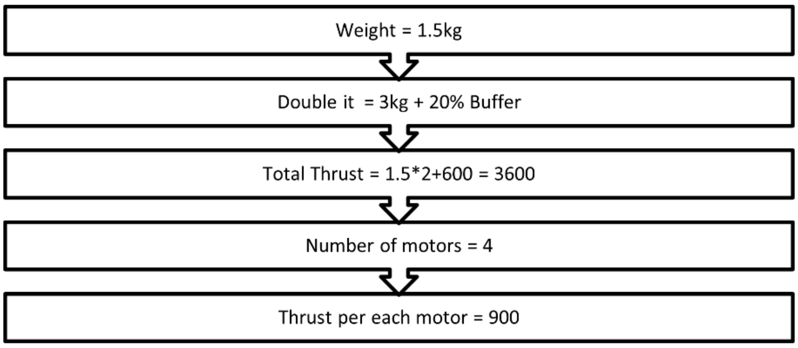

Figure 2 Thrust Calculation.

Selected Motor: A2212 1400KV

3. Propeller

UAV propellers are described by 3 main parameters, diameter, pitch, blades. We will be using F450 Drone frame, which basically means it is an X configuration frame measuring 45 cm diagonally, keeping this dimension in as reference the diameter of the propeller isfixed. With the thrust of 900 g per motor going through various pitch and surveying bench test of A2212 Motor, we found out a 1045 Propeller generates sufficient thrust of our drone.

Pitch: 4.5 cm
Diameter: 10 cm
Selected Propeller: 1045

4. Electronic Speed Control

The role of ESC is channelling current from the battery tomotor under sustained voltage. The selection of ESC significantly depends on the maximum current requirement for the motor for A2212 max current rating is 20A. Through the datasheet of A2212, it is specified an ESC of 30Amp works best. Choosing ESC is a relatively simple task we must see its minimum and maximum current rating.
ESC Selected: SIMONK 30A

5. Battery

Battery characteristic for UAV requires high energy density and high current discharge rate. LiPo batteries serves the purpose. Reversing the previous block diagram battery specification can be calculated the required thrust for each motor is 900g, taking into consideration of all the onboard electronics we have, we will be needing a Standard 12V LiPo battery. For the battery capacity, it completely depends on the flight time we want for 3D Modelling.
Battery Rating Calculation:
MaximumRequired current for motor = no. of motors * maximum current capacity of motor
=4*10
=40 Ampere
Battery discharge current (crating) should be greater than current required by the motor
Selected Battery: 12V 5000 mAh (Minimum Battery Capacity)

6. Flight Controller

To control all the onboard UAV circuits and sensor we will be using open-source flight controller, which provides higher number of peripherals to be attached and has on board circuit to help transmit data to and from the user control. Following is the default list of features we will be needing to carry our 3d mapping

- Gyro stabilization: It is the feature to keep the UAV stable and level under the set input.

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- Altitude levelling: Keeping the copter orientation stable during altitude hold.
- Altitude hold: It is the ability to hover at a certain distance from the ground without having to manually adjust the throttle.
- Waypoint guidance system to map out the area to be under 3D reconstruction.
- GPS system to get the real time location of drone and respective data (latitude longitude altitude)

Considering all the above factors we went for APM2.8 Flight Controller.

IV.II Image Tracking Design and methodology:
The working of implementing Object tracking for 3d modelling using photogrammetry. Image extraction is one of the components necessary for 3D construction using photogrammetry. Image extraction is the process where a common feature among different pictures of the same object is extracted. The camera calibration and image orientation task can be performed when a maximum number of common visible features are extracted. Camera calibration defines the intrinsic as well as the extrinsic parameters. Characteristic dealing with camera internal parameters. Extrinsic parameters observe the position and the orientation of the frame. Two ways to decidingsettings of camera parameter:
1.Directly referencing the camera specification provided by the manufacturer.
2.Conducting calibration processes.

As the surrounding/environment does not remain the same for all the objects. Therefore, intrinsic camera parameters should be calibrated depending on those surroundings. The 2nd procedure should be more effective than the 1st.
The calibration usually involves two steps:
1.Collecting calibration photos
2.Estimating the camera parameters from the pictures.

Calibrationis done on the sample pictures which are captured by the user at the start of the process. if the focal length varies, the user can conclude with the same internal camera properties which is based on calibration results.
Image orientationdefines the relation between the position of the camera and region of interest. Point marking is the process of identifying the points on the photos to inform the modelling algorithm what the coordinates of the points are. More the number of image data better the chances of creating a detailed 3D model of the object of interest. But that is not true, as more images would require more computational power. As the number of image data increases, the chances of overlapping of similar points in the images will increase which may reduce the efficiency and accuracy of the 3D modelling algorithm. To reduce error, the desired point should be covered in more than three pictures. We can reduce the error with the help of other two if the position of the point in any single picture is incorrect. The above diagram helps us understand the point marking needed for aerial photography to create a 3D model. For point marking, there should be an optimal number of 4 levels. These levels depend upon the dimension of the objects.

At set 1, the angle of the camera with respect to the object should be 0 degrees.
At set 2, the angle of the camera should be 45 degrees.
At set 3, the angle of the camera should be 80 degrees.
At set 4, the angle and the height of the camera depending on the user.

The rate of the images captured by the camera at every set depends on the similarity between the 2 images. Object tracking algorithms are used to track the region of interest. The main application of these algorithms is to centralize the object of interest in the frame (image).
There are many objects tracking algorithms available:
1. MIL
2. BOOST
3. TLD

The comparisons between these object tracking algorithms are based on 3 factors:
1.Success:
The ratio of the area of the overlapping and the area of the union. TLD was not the best algorithm when compared to others. There may be two reasons for this. The first reason may be, Boosting and MIL algorithms are classified as pure trackers and are recognized due to reinitialization from the ground truth. The second reason may be, that TLD

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algorithms are highly self-correcting as the bounding box tracking the ROI shifts a lot in each frame which makes it different from the ground truth.
2.Precision:
Is Scale ratio, If the object is located precisely, comparing bounding rectangle dimensions to the ground truth. Higher the precision if the more similar the box is to the ground truth.MIL is the more precise than the other two algorithms.
3.Time:
Total time calculated for each algorithm needs for processing a single frame. The slowest among all the algorithms is TLD. The reason behind the slowness may be the lack of optimizations and their robustness.

Table 1 Comparison of object tracking algorithms.

Algorithms:	Success:	Precision:	Time:
1. BOOST	2	2	2
2. MIL	2	3	2
3. TLD	1	2	1

The above table states the rating of the object tracking algorithms are out of 3, '1' being the lowest and the '3' being the highest rating. The algorithms are rated based on three parameters: Success, Precision and time.

IV.III Control object tracker:
Object detection will provide the system with the X and Y coordinates of the object of interest. The Object tracker contains 2 servo motors which will help to centralize the object of interest by moving the motors in the X and Y-axis. There will be 2 loops running simultaneously:
•Object tracker yaw loop to control the movement in X-axis.
•Object tracker roll loop to control the movement in the y-axis.

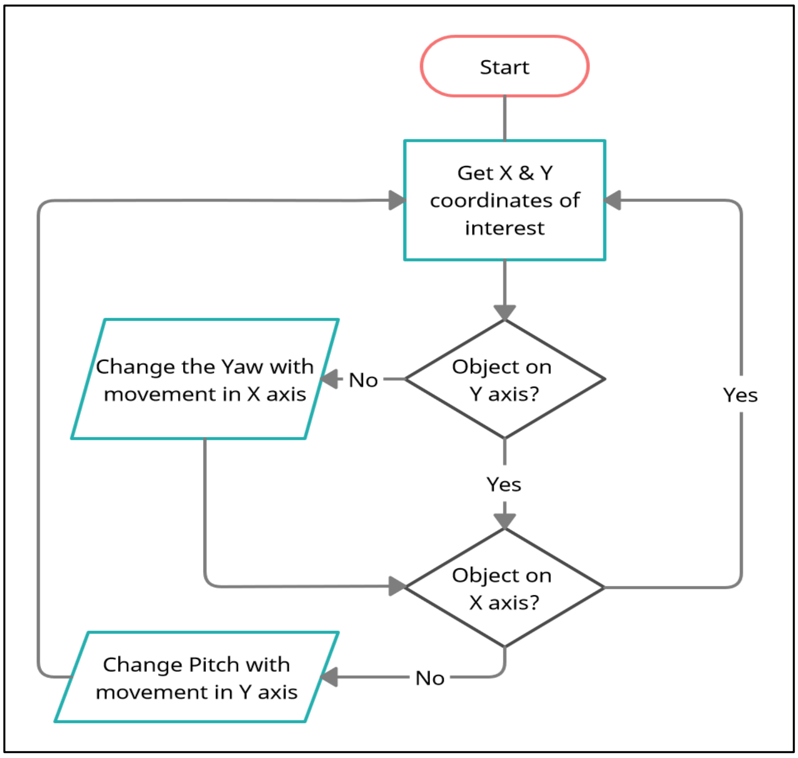

Figure 3 Movement of two axis of gimble

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V. RESULTS

Object tracker program output:
Basically, the output of the object tracker is visualized in multiple frames.
These frames are:

1.**Object Tracking Frame:**

Figure 4 Object Tracking Frame

This frame displays the working of the object tracking algorithm on the object of interest. It also displays the FPS and the X, Y coordinates of the object.

2.**2-D projection:**

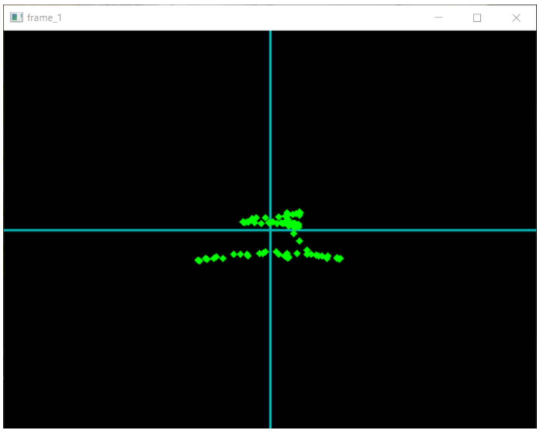

Figure 5 2-D projection

This frame visualizes the movement of the object of interest in the X and Y coordinates.

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3.**Selection and tracker frame**

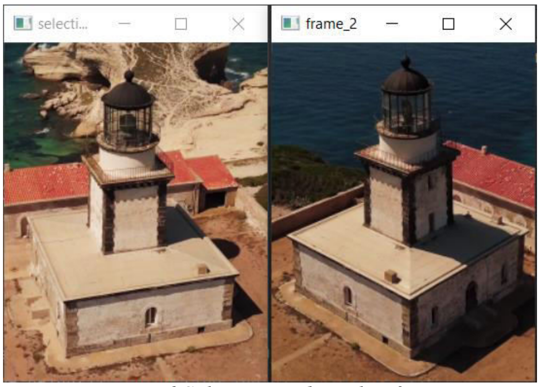

Figure 6 Selection and tracker frame

The selection frame displays the initial picture of the object. While the tracker frame displays video, which contains the selected region of interest.

4. **3D Model Result**

Model is created thorough open-source photogrammetry based 3d modelling software called meshroom.

Figure 7Side View of model

Figure 8 3D model of tower

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VI.APPLICATION

Land-based surveillance methods are costly and consume a lot of time. Using a UAV reduces time and utilizes fewer additional resources. Using UAV one can reach areas that are otherwise impossible or hard to reach by land thus expanding the territorial coverage. Using a UAV is more efficient as it captures a larger area than standard methods.

1. Archaeological Sites

Discovery of findings during excavation and to get to know the current state of the excavation 3D modelling turns out to be especially important. Archaeological sites contain a lot of data necessary for understanding ancient cultures and history, so it becomes especially important to not damage any such relics or inscriptions and thus there is a need to carry out a precise excavation plan. UAV can help overcome this issue by going inside the area/room and giving a 3D model which can later be used to efficiently plan an excavation at a low cost.

2. Mining

Companies aim to adopt safe, efficient, and cheaper ways to mine. UAVs are helpful as they can cover wider and different areas for surveying. Volume, Slopes, sturdiness, and surface can be obtained from dense point clouds of the scanned area. Terrestrial laser scanners can be costly and slower as compared to UAVs.

3. Cartography

Mapping and cadastral applications can use UAVs for the surveillance of urban and rural areas. To obtain a detailed digital surface model (DSM), images with high resolution (100 – 200m from the ground) and overlap can be taken for mapping. High-quality DPC's can be used for feature extraction and analysis.

VII. CONCLUSION

We have developed this article to explain the working of 3D construction of model of choice using Aerial photogrammetry. We explained in detail the concept of 3D modelling and the process required for creating a model. Our main aim was to show that, the above can be accomplished with the help of UAV and aerial photography. We have implemented various object tracking algorithms and compared it with each other which has been evaluated in tabular form. The use of the 3D modelling software and the pipeline that the user has to follow has also been stated. The work has been done in Python-OpenCV as it is very flexible, easy and the execution time is very less as compared to others. To conclude, our project can be of a great help in fields such as Surveillance, Archaeological, Cartography and Construction. The project can be modified/upgraded using AI and deep learning to create more efficient, sophisticated 3D models using images.

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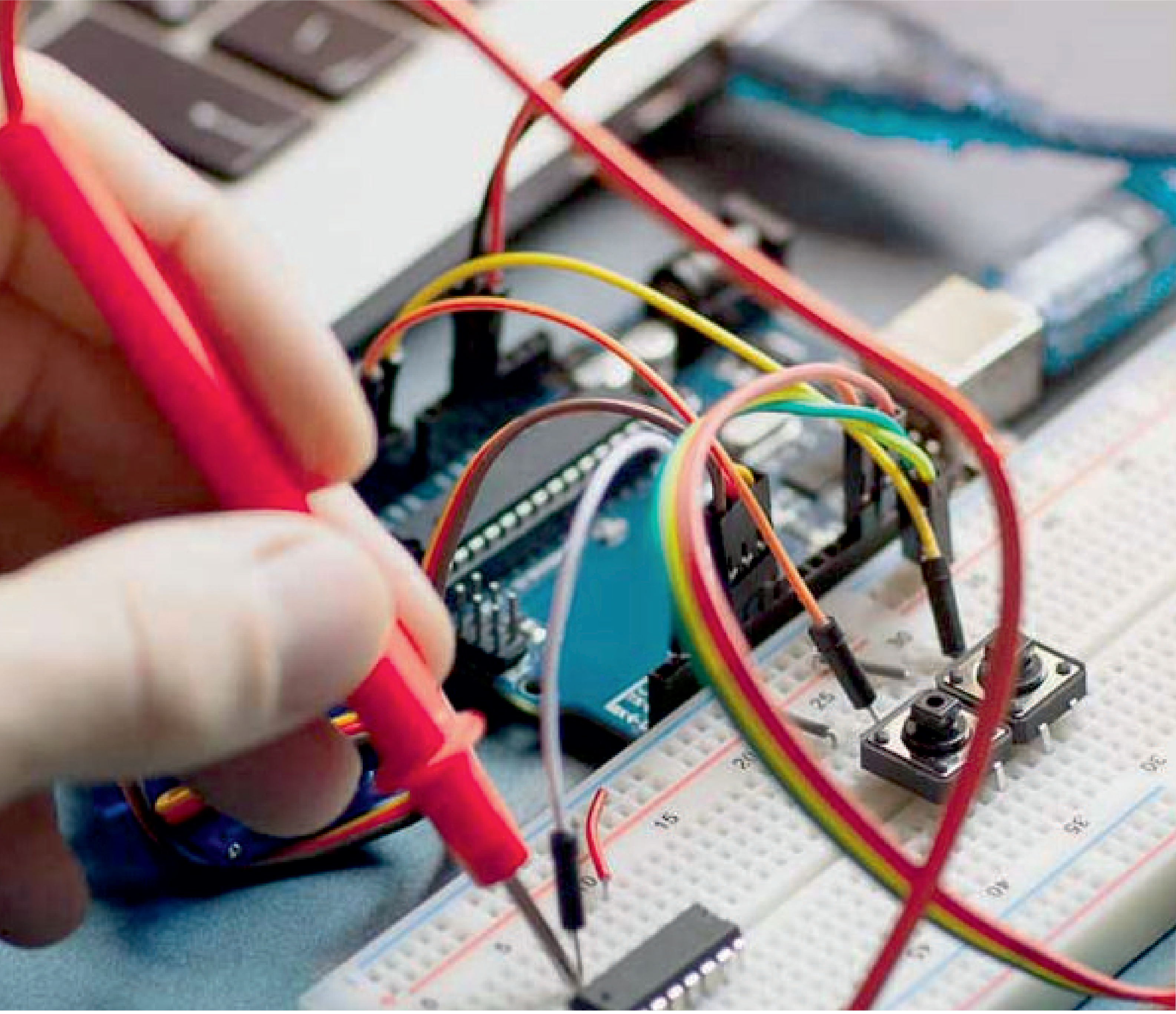

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