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CRAWLING ROV FOR IRREGULAR TERRAIN SEAFLOOR DISCOVERY

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ABSTRACT

Underwater Remotely Operated Vehicle (ROVs) have a significant support role and play a dominant underwater robotics which has very high demand in marine and offshore field. A bottom founded-ROV give an additional value from normal ROV to expand research and survey on seafloors. Known as UniKL Amphibious Research Crawler I (UARC I) is designed to operate underwater and in the surface zone up to a depth of 15 meters and it equipped with the video camera. This vehicle is controlled by a controlled cable from the beach or boat up to the distance of 15 meters for inspection and seafloor discovery. This vehicle is specially designed to withstand with the Malaysia irregular terrain seafloor. The simulations of the dynamic motion for climbing over a hump and the slip characteristics shows the vehicle can work very well, and it reveals the physics of the crawler-type ROV's motion. Capable of carrying the load up to 15 kg with the body weight of 13.5 kg it can allows the enhancement with the robotic grips or additional accessories in the future. It is good start to fabricating the light weight crawling ROV with effective cost and can works at any asymmetrical terrain and sand.

Keywords: Crawling ROV, irregular terrain, light weight.

INTRODUCTION

National Ocean Services (2015) defined the remotely operated vehicle (ROV) is an unoccupied underwater robot that is connected to a ship by a series of cables or in other words is defined as a tethered unmanned underwater robot. Nowadays, this vehicles are widely used for many application and purposed for underwater mission such as tracking sinking ship, underwater exploration, underwater survey and inspection or even widely used as research tools. This application technologies have increased rapidly over the last few decades. However, the model of the built ROV are free flying, but only few are built for crawler type running either on tracks or wheels. Hence there are many types of ROV, crawling ROV running are seldom built due to limitation of usage. Many cases this model not successfully in their mission due to limitation of wheels or tracks to operate in different type of seafloor and terrain. Even though it seldom built, in some cases these systems are crucial because of the varying operating condition on seafloor area are a must in certain condition. If looking for this kind of usage, it is important to looking for the development of crawling type ROV model.

Looking to the readymade crawler type running ROV in the market, normally it will more costly compare to the normal type model with the same range of specifications. It is important to think and built the effective cost model with addition to overcome the working limitation on seafloor especially to fulfil the Malaysia seafloor condition. This paper presents the design and development of bottom-founded running ROV or known as UniKL Amphibious Research Crawler I (UARC I), which is a crawler integrating with Remotely Operated Vehicles (ROV) for underwater inspection. These model are aims to operate on the seafloors with inconsistent or asymmetric surface and precipitous terrain, water tank/ dam and reservoir.

Crawler type

The Crawler type ROV or named in this project as UniKL Amphibious Remotely Operated Crawler I (UARC I) are define to have the main body, integrating crawler and the accessories compartment. The limits of working model are range in precipitous terrain having slopes of around 30° in some areas. The seafloor working area can be uneven with assumed impropriety of 20– 50 cm. This model need functions to shift and perform the reaction force of operations. In common the ROVs during operation should be remain motionless or in static position and keep their stance stable. For conventional ROVs it is important to consider the action during coring, which is an important role of function. For those that has hover it's generally perform the reaction force by their weight or thrusters.

However, this is sometimes insufficient for performing large forces, which limits the ROVs operation. The small conventional ROV unit, it will equipped with the propeller motor to move in water but, it would not have the function of operating on the seafloor. The attachment of crawler it's also help to improve the flexibility of a ROV on a variety of seafloors such as sand, rock reefs with inclinations of more than 30°, and seafloor covered with cobbles or gravel or even to in a water tank/ dam. At sea, this unit is confirmed has advantages in performance which it's flipper-type crawler system. With the enhancement at the tracks the model is expected to operate on seafloors with irregular terrain and climb over humps compared to the conventional crawler system. While the general wheels mechanism s are not suitable for such rough environments, the robots moving mechanism

need to be flexible to various environments. This flexible movement on irregular terrain are illustrated in Figure-1. It shows three types of mechanism on irregular terrain with shows the difficulties of each type illustration movement.

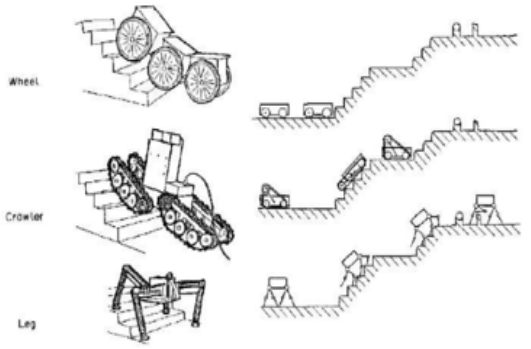


Figure-1. Robot moving mechanism.

UARC I development and construction

The development of ROV and crawler integration are necessity for the seafloor research and exploration which requires custom types ROVs to operate in various surrounding environment. The common ROVs equipped with three or more thrusters or propeller to move in water, but it will lack of function to exploring the seafloor. Integrating with the crawler will give an advantaged to the ROV unit for working on the seafloor. The propeller system which is modified from the thruster are attached to the unit will helps to improve and expand the mobility through any condition of the seafloor environment. The modified thrusters are used to move the direction of the ROV. The compartment for the accessories such as several dexterous manipulators, video cameras, tools and other equipment are detachable to the unit.

The construction of UARC I is start from scratch design with the basic chassis which attached to the crawler ROV. The free maneuvering of the UARC I at different seafloor, the crawler are enhance with the crawler system and the roller. Figure-2, shows the UARC I construction flow chart. The system block diagram explained the concept of the UARC I which are divided to two part, first part is surface system and second part is sub-surface system as shown in Figure-3. The chassis for the unit are constructed with the aluminum rod to give a good strength with light weight and effective cost. To attach the moto and other necessities to the unit., ABS material was used and fabricated by 3-D printer technology. The circuit or the unit is custom design to suit with the 12VDC and 220VAC compatible.

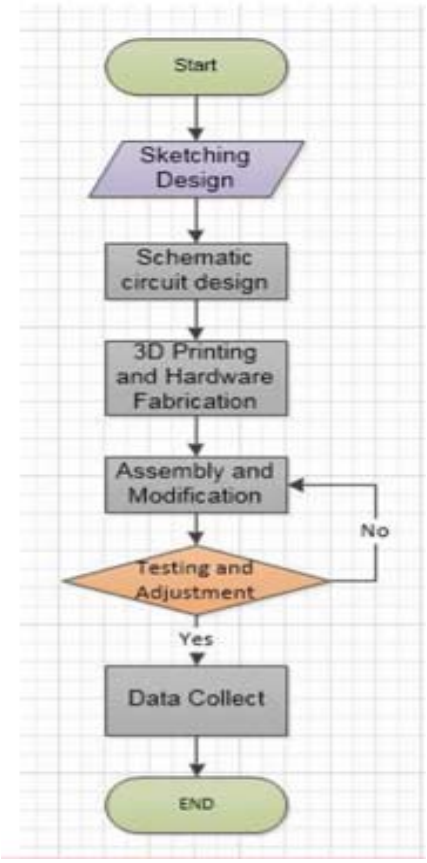
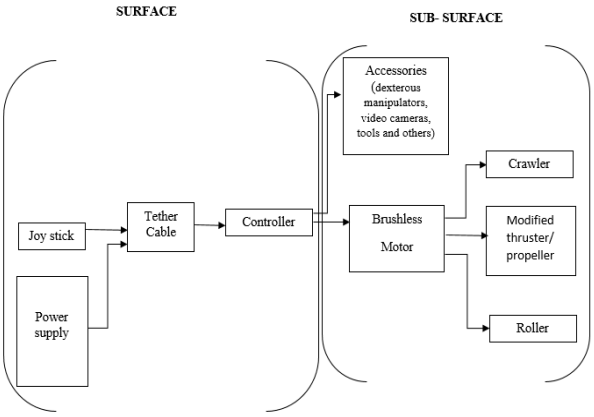


Figure-2. UARC I construction flow chart.



Figur-3. Principle of UARC 1 block diagram.

Figure-4. Is the sketch design of the crawler system shows in isometric view for UARC I using inventor software. From this isometric view, it clearly shows the connection of the crawler and the innovation of roller attached to the main chassis and the crawler itself.

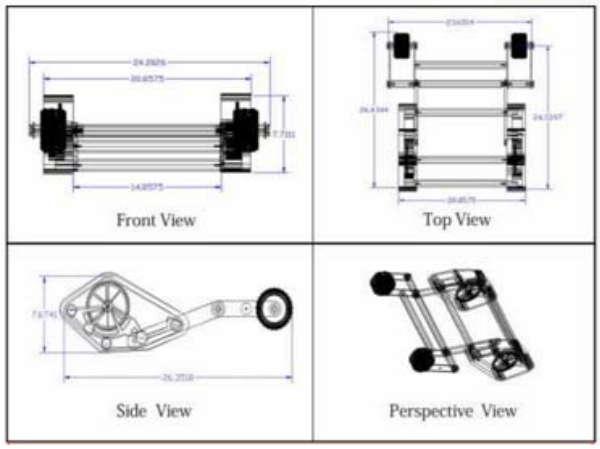


Figure-4. Isometric view of crawler sketch design using inventor.

Figure-5. Shows the basic fabricated model of UARC I, with attached controller and tether cable for surface part and the crawler unit for sub-surface part. The accessories are detachable to the main unit of UARC I.

Figure-5. Basic system of UARC I without detachable accessories.

UARC I performance test

The UARC I unit is power up using the power supply which it will initialize the system. LED indicators is 'ON' to indicate the 220VAC power supply to the unit and shows the PSU 12 VDC is operational. The system initialized will allows the UARC I pilot to pull the trigger to power up or down the motor, the positioning of unit and too control the motor either forward or reverse. The voltage will be channel to the connector in the subsea port on the crawler and perform the task given by activated the motor needed by pilot. UARC I have been tested at 15 meter deep underwater with the irregular terrain slope around ~30º seafloor and the slope ~30º on cement floor on land. The results are shown in Table-1 and Table-2. In Table-1, the UARC 1 are tested on land, the distance was tested is 3000 cm. The load given to the unit is between 0 Kg up to 15 Kg. The result shows the speed is reduce and the time taken is significantly increase with the additional of load to the unit. In Table-2, it shows the UARC 1 testing at 15 meter depth with the distance 3000 cm at 30º slope. Time taken to complete the distance given increase and the speed reduce significantly. The percentage of uncertainty speed for the UARC 1 based on the underwater testing at depth ~15 meter have been calculated. The on land result shows the speed percentage of uncertainty is ~ 6.36% while underwater testing at 15 meter depth ~ 5.54%. Based on this calculation the speed reduce in underwater at 15 meter depth is ~ 0.82%. Commonly known that the resistance underwater is higher compared to on land, since on land the resistance only depend on the air resistance. While underwater resistance is increase significantly with the factor of water itself, depth, pressure and the underwater wave/ current. It shows that in principle this data is parallel to the principle theory, but the testing must repeat to reduce the uncertainty factors to get more accurate data at different depth and degree of slope.

Table-1. On land UARC 1 performance testing at 30º slope.

Load (KG)	Result (on land)		
	Distance (cm)	Time taken (second)	Speed (cm/s)
0	3000	6.38	47.02
5	3000	6.50	46.15
10	3000	6.63	45.24
15	3000	6.80	44.12

Table-2. 15 meter depth underwater UARC 1 performance testing at 30º slope.

Load (KG)	Result (underwater)		
	Distance (cm)	Time taken (second)	Speed (cm/s)
0	3000	6.51	46.08
5	3000	6.62	45.32
10	3000	6.79	44.18
15	3000	6.88	43.60

CONCLUSIONS

UniKL Amphibious Research Crawler 1 is successfully integrate for use in different type of seafloor at irregular terrain slope around ~30o seafloor and the slope ~30o on cement floor on land. The performance on UARC 1 was shows the good manoeuvrability in term of handling and on land and underwater. The integrating of crawler and roller gave an advantages to UARC 1 to work

on seafloor at depth of 15 meters in Malaysia condition underwater environment. The technologies used are local made using basic foundry facilities, basic electronic devices and 3-D technology, which can considered as cost effective. The dimension of UARC 1 is 25 inch x 20 inch x 7.7 inch and the total weight excluding cable at ~15 kg. The dimension, weight and simple technologies was used and simple features of application are suitable for a beginners to learn and explore the underwater world which benefit to the research, inspection, rescue and educational field. The fabrication cost is affordable compared to the existed product.

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