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Polystyrene Foam-based Leg Tip Strider Robot

Ai Chern Lim
Faculty of Electrical & Electronics Engineering,
Universiti Malaysia Pahang,
Malaysia
jayness89@hotmail.com

Addie Irawan
Robotics & Unmanned Systems (RUS) group,
Faculty of Electrical & Electronics Engineering,
Malaysia
addieirawan@ump.edu.my

Abstract— **This paper presents the water strider robot design with polystyrene foam-based leg tip approach. With reference to the biological size and flexible maneuverability of water strider this robot suitable to be applied as autonomous instrumentation unit for water quality monitoring application. The density of the main body is designed with less than 1g/cm^3, which is less than density of the water. Four motors are placed at the four side of the robot's body and driven by two half-bridge drivers via a microcontroller. The system is remotely control via computer unit through 3DR Radio module. According to the analysis on various experiments it shows that the size of polystyrene foam and the degree of copper leg play important role by supporting the robot's body and the floating of robot on the water surface.**

Keywords—quadruped configuration, polystyrene foam leg, 3DR Radio module

I. INTRODUCTION

Water strider or Gerridae is an insect that can stand, walk even jump on the water without sink. This light and small insect used high surface tension of water and its long leg with hydrophobic micro hair to repel the water and preventing drops from weighing down the body. Therefore through the observation of this creature, the strider robot have designed by several researchers with different approaches such as Water Dancer IIa [1], water walking robot [2] and STRIDER II [3] are example of robot that inspired from Gerridae biological structure and behavior. Water Dancer IIa is developed with tele-controlled using infrared signals with capable of turning and speed regulation. In addition this strider robot is designed with lighter structure material and low power consumption.

Another water strider robot with novel buoyancy based water decoupled parallel mechanism with three micro electromagnets [4]. Moreover the dynamic model of driving mechanism is built according to kinetic energy theorem for striding purposes. On the other hand, piezoelectric unimorph actuators have been designed and implemented for another water strider robot reported in [5]. This Piezoelectric driven water strider is designed with multiple actuators to create complex motion since this actuator only available for one degree of freedom (DoF). It is different to water strider robot proposed in [2] whereby spring actuation mechanism is used. This robot consists of four supporting legs and two actuating legs, a micro DC motor, two springs and a set of gears allows under-actuating mechanism applied on striding period. The STRIDER II has different focus on water strider robot balancing and striding solution. This robot used novel circular footpads for high lift, stability, payload capability and a new elliptical leg rotation mechanism for more efficient water surface propulsion stated in [3]. Furthermore, STRIDER II's circular footpad is designed in order to increase the total length subjected to lift force while keeping the total area of the supporting structures relative small. According to the existed strider robots [7-12], most of the design is emphasized on balancing and stable striding including the special material design although some of the design has creating boating system rather than striding system.

Therefore, this research has taken initiative to propose another approach of strider robot by using sponge as a leg tip. The proposed polystyrene foam-based tip strider robot is designed with economic components that consist light transparent perspex sheet as body structure material, PIC microcontroller unit (MCU), dual driver for each four micro-motors driven and radio frequency (RF) wireless module. This article will discuss the overall design of proposed polystyrene foam tip strider robot, the polystyrene foam -based tip and leg design and discussion on the measurement and analysis of leg/tips design.

II. SPONGE-BASED LEG TIP STRIDER ROBOT SYSTEM CONFIGURATION

The polystyrene foam -based tip water strider robot is designed with two layers of body structure consists of electronics control board (top) and cover (bottom) with dimensions as shown in Fig.1 and Fig.2 respectively. For the bottom body frame part, all components are placed on the center of the body frame including couple of 12V A23 batteries, two 3V coil batteries and 3DR wireless module. On the other hand, fours micro-DC motors are placed every each diagonal side of body frame.

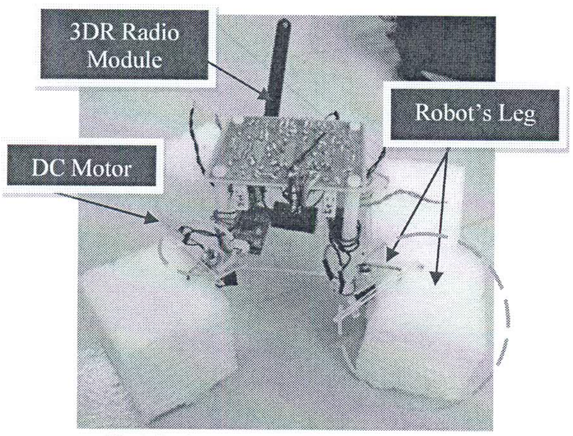

Fig 1: Body Structure of Water Strider Robot

The electronics control board is placed as an upper layer attached with the perspex frame on the bottom side. Robot's leg is attached on each side of the bottom (motor shaft) as shown in Fig.1. The dimension of sponge-based tip strider robot is designed as shown in Fig.3 and 4. The size of the polystyrene foam as shown in Fig.3 is decided using several experimental that will be discussed in Section III including the degree of copper-based leg as shown in Fig.4.

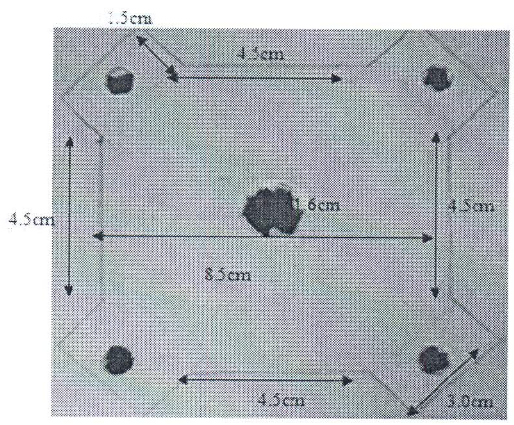

Fig 2: Dimension of polystyrene foam -based water strider robot body frame

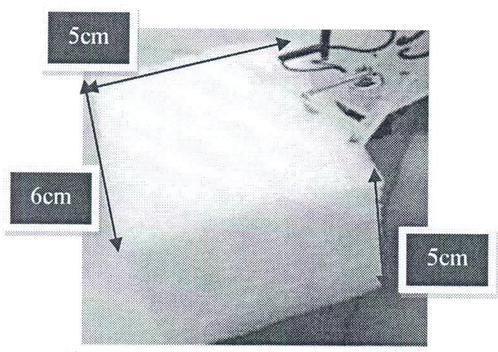

Fig 3: Dimension of leg tip using polystyrene foam

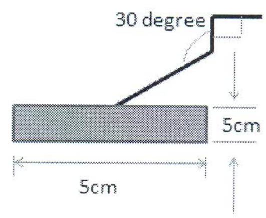

Fig 4: Polystyrene foam -based tip water strider robot leg design

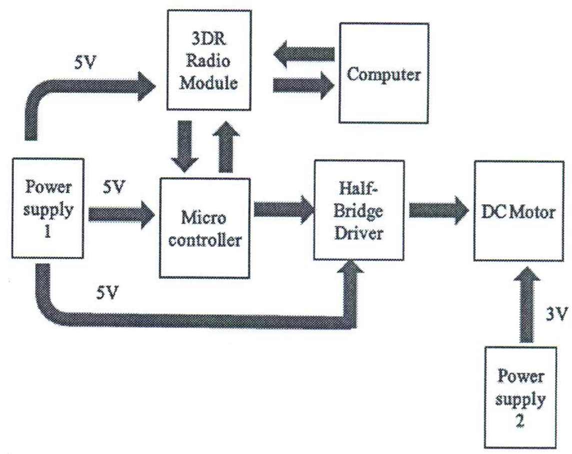

Fig 5: Block diagram of electronics control unit for sponge-based tip water strider robot

As for control purposes, the architecture of control unit for the proposed polystyrene foam -based tip water strider robot is designed as shown in Fig.5. There are two main module which are driven module and communication module that played a main role for the system. Integrated dual half-bridge has been used for each couple of micro DC motor as driven module from microprocessor unit.

On the other hand in communication module, 3DR radio module is used for remotely control purposes from computer unit and PH data acquisition (PH sensor attached on center of robot body). The distance of communication module is approximately 1.5km that makes this strider robot able to remotely control for long distance navigation.

III. MEASUREMENT AND ANALYSIS OF SPONGE-BASED TIP DESIGN

As shown in Fig 6 is the comparison has been done for different size of polystyrene foam with different degree of leg angle. According to this result, there are two type of dimension of polystyrene foam with various degree of leg possible to be used.

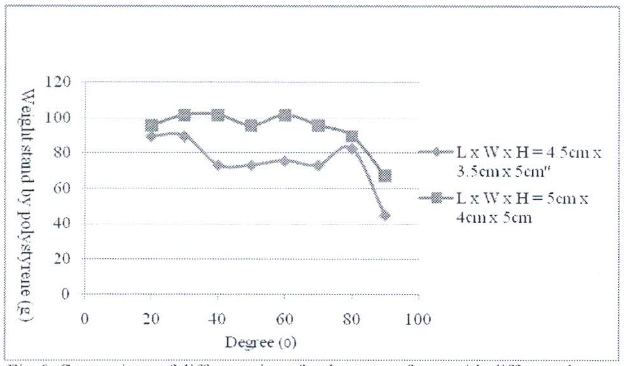

Fig 6: Comparison of different size of polystyrene foam with different degree

The polystyrene foam has cut with the first dimension which is 4.5cm x 3.5cm x 5cm and the copper leg is bending to 90 degree for the first try. After installed the polystyrene foam leg on the four side of the robot's body frame, the robot is put on the water surface and different size of rubber corks are put on the surface of the body frame until the robot sink under the water. The copper leg is bend to 80 degree with the same dimension of polystyrene foam, same procedures are repeated until the robot sink under the water. The same experiment is conducted until the copper leg is bending to 20 degree. Moreover, the same experiment is done for the polystyrene foam with dimension of 5cm x 4cm x 5cm and the result is shown as Fig.6.

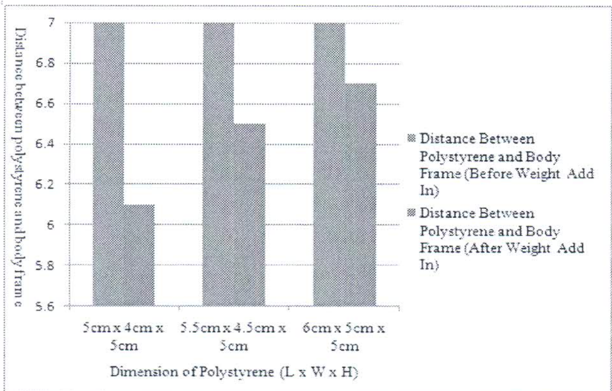

Fig 7: Experimental data for size of polystyrene foam

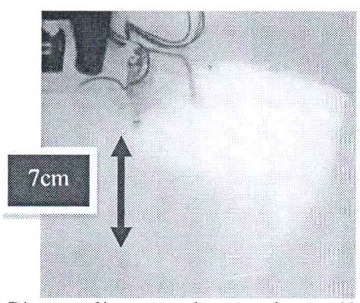

Fig 8: Distance of between polystyrene foam and body frame

Overall results in Fig. 7 show that 30 degree is the angle of leg that can stand the heaviest weight of robot's structure (≈134g). However, the suitable size of the polystyrene foam still not able be decided yet in this experiment. The experiment is further to determine the size of tips as shown in Fig. 7.

As shown in Fig. 7 and 8, the original distance between polystyrene foam and body frame is 7cm for three size of polystyrene foam tips. The different can be seen when load is added as shown in Figure 7. According to this result the bigger size of polystyrene foam, the better of the robot float on the water surface. This is because the distance between polystyrene foam and the body frame getting shorter with increasing the size of polystyrene foam. The size of 6cm x 5cm x 5xm is the best size of the polystyrene foam tips for this water strider robot by taking the body structure size and striding limitation factor.

IV. CONCLUSION

In conclusion, due to the small size, light weight and ability of floating on the water surface, it can be applied on various surfaces and channels of water including culvert, mangrove, small creek and lake. It can help human to reach the deeper place that human hard to get in, this can help the further development of human research and also help to reduce the risk that will be faced. This water strider robot still has many improvements that can be improved in the future. In the future, this water strider robot may be able to be produce in smaller size with more function that can contribute to the social.

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