ME 4773/5493 Fundamental of Robotics
Fall 2016
San Antonio, TX, USA

VIBRATION BASED ROBOTS: RUNNING AND CLIMBING

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ABSTRACT:

The vibrational effects of three different robots were examined using small dc motors. For the first two experiment bristle bots were created from an ordinary toothbrush and a large scrubbing brush. The movement behavior of these bristle bots were examined as the DC motors were left to run indefinitely. The last experiment consisted of using a single DC motor and allowing it to run inside a vertical elliptical tube and observing the motions caused by its vibrations. The outcome of the first two experiments with the bristle bots showed that the larger the bristles, the larger the displacement of the bot. They also demonstrated that when hitting an obstacle, the bots would circle around the edge. The second experiment showed that friction between the edges of the motor and the tube allowed "climb" relatively fast up the narrow tube. Although these small autonomous robots might seem seemingly useless by themselves, they can have countless of possibilities in research and development which can help mimic swarm interactions in nature and other microorganisms.

1. INTRODUCTION:

Vibrobots are simple tiny self-propelled autonomous robots that use the vibration of the motors for locomotion. They are widely used in biological research seeing as they mimic the pattern movement of microorganisms, animal behaviors, and other natural processes. A single vibrobot is seemingly useless as it follows a disordered pattern, however a swarm of these can form organized motion. The most widely known and used vibrobots are called bristle bots, which are cheaply and easily made, making them popular amongst school science fairs. They are mostly made from small toothbrushes and tiny vibrating pager motors. The vibration of the motor causes the bristles to bounce up and down, hence resulting in the forward motion. With tilted bristles, the bot is able to move more rapidly from that vibration to scoot forward [6]. As these bristle bots encounter hard boundaries, they tend to circulate along the edge of the boundary due to the rotational movement they exhibit, which brings us to the topic at hand. As the boundaries become much more constrained, the bristle bots use this vibration to travel along the path created, using friction to travel up the slopes. The following experiment will explore and demonstrate the validity of this concept.

2. METHODS:

To demonstrate the running motion of the bots, two bristle bots were created using common household items. The first one was made out of an ordinary toothbrush, a tiny vibrating pager motor found in cellphones, and a lithium coin cell. The top portion of the toothbrush only containing the bristles was cut off. The motor and the battery were mounted on top of this brush using tape to hold them together. For full functionality the motor was placed so that the motor slightly tapped the top of the brush, causing the bouncing movement. The wires of the motor were connected to the battery which started the motors. The final product is shown in Figure 1.

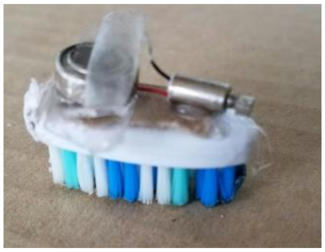

Figure 1: Small Bristle Bot

A second bristle bot was constructed using a large scrubbing brush. All handles were cut off from the top, leaving the top bare. A small dc motor was place at the edge of the brush and glued in place. A 9V battery was rested toward the back end and aslo glued to the top. A plastic pottle cap was glued to the rotating part of the motor, slightly touching the brush which was used to actuate the vibrating motion when the motor was turned on. Silicone from a hot glue gun was added to one side of the cap to add weight and increase the vibration. Finally, the wires from the motor were connected to the battery to turn on the motor. The figures below show the isometric (2) and top (3) views.

Figure 2: Isometric View

Figure 3: Top View

A small arena was created on the floor using cardboard as hard boundaries to observe the behavior of these bots while in motion. The running motion of each bot was observed independently and annotations were made regarding their behavior.

The final concept that was explored in this experiment was the climbing motion of the vibrobot. A single DC motor was used for this concept. Silicone from a hot glue gun was added at the top and bottom edges. This was done to ensure there was enough friction between the motor and the wall. Silicone was also added to the bottom portion of the rotating shaft of the motor to create vibration, Figure 4, similar to the miniature climbing mechanism, Figure 5, explored by A. Degani, et al. [3]

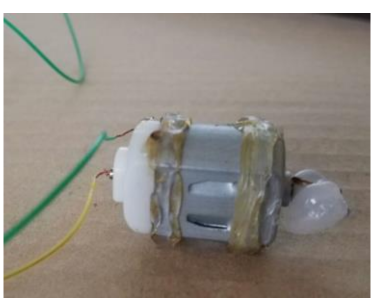

Figure 4: Climbing Robot

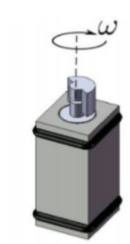

Figure 5: Miniature Climbing Mechanism

A 9V battery was attached to the motor using very long wires which would allow the motor to travel a distance greater than 4 ft, the length of the tube used for testing. The tube was modified so that the circumference became elliptical, Figure 7, increasing the contact points of the motor.

Figure 7: Elliptical Tube

The motor was started and allowed to run inside the tube. The observations were recorded and analyzed in the following sections.

3. RESULTS:

The small bristle bot's vibration maintained it rotating in place. There was very small displacement with respect to the motor. The bigger brush had a much larger displacement when the motor was turned on, however much of its motion was sideways with respect to the direction of the brush. The small climbing robot moved very rapidly up the pipe and once it reached the top, it remained vibrating in place.

4. DISCUSSION:

The results from this experiment demonstrated that the bots that have longer bristles are more likely to travel in a much more straight line with respect to the location of their mass than those with shorter bristles, as they are able to displace the center of mass on much further with each step. Shorter bristles tend to be noisier and have more short sporadic movements. The larger bot tended to move sideways, more likely caused by the placement of the motor off the center and to the side. Another likely factor would have been the direction of the bristles and the length. Some brushes tend to have different size bristles which allow for better cleaner. A good way to have offset this would have been to cut all bristles to the same size. The smaller bristle in this experiment hardly moved locations, rather it stayed vibrating in the same place. To increase movement, it would have been better to increase the contact area of the motor by bringing it closer to the brush, allowing for greater vibration.

The upward movement of the bot inside the tube is due to the constant rotational movement generated by the constant velocity of the motor. This constant oscillation allows for each opposite edge, along the diagonal, to come in contact with the wall, using friction between the rubber edge and the wall to maintain it at the position and the vibration to propel it forward. The smaller the diameter of the tube, the faster the bot is able to travel since the bot comes into contact with the wall at a much faster rate than that with a bigger diameter. The placement of the motor at the front played a major role in determining the direction at which the robot was moving. Placement of the motor towards the upward direction of the tube allowed it to move forward. Had the placement of the motor been contrary, the bot would have moved downward rather than upward. Placement of the motor midway on the bot facing upward would have caused the bot to move much more slowly.

5. CONCLUSION AND FUTURE WORK:

This project explored the vibrational effects on three distinct robots. The first two homemade bristle bots demonstrated the running motion was in direct correlation with respect to the length of the bristles and placement of the motor. The vibrobot in the third experiment also demonstrated the importance of the motor placement. The closer it was to the front, the faster it propelled itself forward. A most notable characteristic in all three experiments was the bots interaction with hard boundaries. As they encountered a boundary, they tended to follow along the circumference of it due to their rotational tendencies in the same direction. A better way to examine these bots would have been to also study further their dependence on different boundaries an interaction with each other in swarms.

Further research in these tiny autonomous bots can be beneficial when studying random natural processes. A swarm of these bots can mimic certain microorganism characteristics which are often random in nature. They can go from being random to having organized movements.

ACKNOWLEDGMENTS:

The authors would like to thank Dr. Pranav Bhounsule.

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