Study and Modeling of an Underwater Cleaning Robot

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ABSTRACT
The development of new technologies in urban automation has increasingly intensified in recent decades. Among the research initiatives, there is the study and design of service robots for home tasks, such as: cleaning floors, windows, and pools. The technology used in these robots depends on specific resources and great investments, and consequently, the price is expensive, restricting the use for people with high purchasing power. Thus, it is important to study means to manufacture robots with better cost-benefit, looking for to develop mechanisms that can reduce the production costs, and then a greater number of people can use such technology. Therefore, the objective of this work is to develop an underwater cleaning robot, which can be used for cleaning pools. Several aspects of the project, a model created by means of computational methods, and some analyses of the robot structure will be presented.

Keywords: Automation, Cleaning, Design, Modeling, Robot, Robotics, Underwater, Urban

INTRODUCTION
In this work, the main objective is the design of an underwater robot for cleaning pools. Basically, the use of available technology to make some housework or just to provide a friendly interface to control the home systems, configure Domotics (Home Automation), which represent a research area of Urban Automation. Some interesting works about Domotics can be seen in Leonik (2000), Alves and Mota (2003), Bolzani (2004), and Meyer (2004).

Even today, domestic cleaning robots are seen as exotic appliances or luxury toys. Cleaner pool robots do not have this kind of problem, establishing itself in the market over the years. The challenge to clean pools (mostly rectangular) is much smaller in comparison to the challenges associated with autonomous lawn mower robots, for example.
The basic mechanism of a cleaner pool robot consists of rotating brushes and two motors, one for the drive unit and rotating brushes, the other for suction, which not only allows filtering of water, but also the robot climb the walls of the pool to the surface.

In relation to navigation, it is customary to use rectangular or zigzag movements, with the aid of the walls (to crash into a wall, or detects a possible collision, the robot reverses direction of motion). There is a sensing to detect obstacles, and the robots have to external supply unit and the presence of a wiring surface.

The cost of this type of robot is high, with values ranging from U.S. $ 800.00 to U.S. $ 850.00. Figure 1 shows some examples of cleaner pool robots on the market today. The robots presented here have a cleaning average performance of 330 m²/h.

In the next sections, we will present a review of the characteristics of pool cleaning machines, as well as the modeling of a robot, necessary to design of a prototype. The pool floor cleaning will demand brushes, and the pool wall cleaning will need a floater. We will also need a pump and a filter. The autonomy will require some sensors and some control devices. In addition, we will see some analyses of the robot structure. This paper is a revised and expanded version of the book chapter published by Lima Jr., Pina Filho and Pina (2012).

FLOATING SYSTEM

Considering the cleaning of pool walls, we can think in two ways of doing this task: by using a sucker or a floating system. A sucker, or an array of them, depends of the wall material, and we do not want to restrain this. Then, the floating feature is the more reliable way to allow the cleaning of pool walls, because it depends only of specific mass of water instead of the pool characteristics.

The floating system (Figure 2) consists of an empty tube, which can be filled of water for submerge. A piston controls the input and the output of water: to get the water inside the system, a steel cable pulls the sealing disc, reducing the chamber pressure. Since the opening is in contact with the pool water, the chamber is filled. When the cable is released, a spring pulls the sealing, increasing the pressure, discharging the water to the environment.

Actually, the input of water increases the equipment specific mass, turning this bigger than water specific mass, then, the equipment submerges. When the floater expels the water, the specific mass of the equipment is smaller than the water specific mass and it floats. Our calculation will assume a Newtonian fluid and the load loss is negligible. Let be \( \rho_w \) the water specific mass, \( \rho_e \) the specific mass of the equip-

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Figure 1. Some examples of cleaner pool robots: (a) TigerShark Pool Cleaner, by Aquavac (“Aquavac”, 2013); (b) Aquabot, by Aqua Products (“Aquabot”, 2013); and (c) Dolphin Diagnostic, by Maytronics (“Maytronics”, 2013)
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