# Design and Prototype Development of a Low-cost Blood Flow Simulator for Vascular Phantoms

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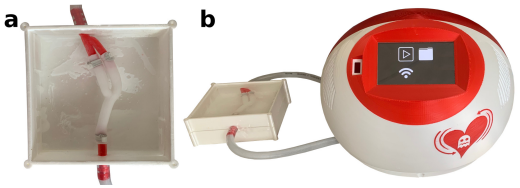
A vascular phantom should be anatomically realistic both in terms of geometry, acoustic and physical properties. Besides, to enhance measurements reliability of in vitro models, it is very important to simulate blood stream according to the characteristics of the vascular portion, reproducing a realistic physiological flow which possibly mimics patient-specific conditions.

In this context, we propose a low-budget flow simulator to produce physiological-specific stream in flow phantoms. In particular, we focused on the development of a flow phantom of a carotid artery. The phantom has two main parts: the hydraulic circuit and the control system. The hydraulic circuit consists in a liquid reservoir, one centrifugal pump, one ultrasound flow sensor which performs real-time flow measurements, and the carotid phantom. The components specifications were selected basing on the analysis of blood flow profile in this artery. Each component is interconnected to the others by a flexible pipe. The control system is enabled by a microcontroller based circuit board (STM32F7-Discovery), that performs the control of the system to achieve the desired flow profile. The main board is connected to a BLDC motor controller board used as interface for the pump's motor.




(a) Vascular Phantom
(b) Flow Simulator Prototype

The circuit board implements an open-loop controller. The input sequence was defined by modelling the hydraulic circuit as a Nonlinear ARX system.

The performances of the designed simulator were tested using an echo-doppler machine. The measurements are in good agreement with the desired blood flow. That means the simulated flow has a maximum deviation of around 10%, than target flow. The proposed simulator allows to realize realistic blood flow profile at low cost ($< €1.500$) and with a compact device, programmable with flow-specific profiles.