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FLOW VELOCITY MEASUREMENT IN OPEN CHANNELS USING COMPUTER VISION

Abstract. In this paper author describes new approach to flow velocity measurement in open channels by utilizing components of computer vision. Placing an obstacle in the open channel creates different turbulence zones around it, and one of them is a wave in front of an obstacle. By connecting the height of the wave in front of an artificial obstacle with flow velocity in the open channel author uses methods of computer vision for experimental proves of suggested method credibility.

Key words: flow velocity, open channel, computer vision, obstacle.

Flow velocity measurements are important for different branches of technology and scientific research. Constant flow velocity monitoring is critical for in-time predictions of flooding and areas affected by it. Existing ways of measurements can be divided in two groups: contact and non-contact. In the first group there are ways of measuring using hydraulic buoys, rotors, turbines as well as hydraulic tubes. Non-contact ways of measuring flow velocity consists mostly of acoustic, radio, and other different wave-based sensors. Existing hydrometric stations mostly utilize hydraulic buoys or rotors due to their low cost and simplicity, but they still need a human operator to perform accurate measurements as well as maintenance.[1]

Suggested method combines contact nature of measurement and modern computer vision technologies to perform accurate measurements and their constant and remote monitoring. It's main idea is to install semi-immersed obstacle in the open flow channel and perform height measurements of a wave that appears in front of it. By connecting wave height with flow velocity we can utilize modern video- and photo- capturing devices to provide both accurate, constant and remote measurements.

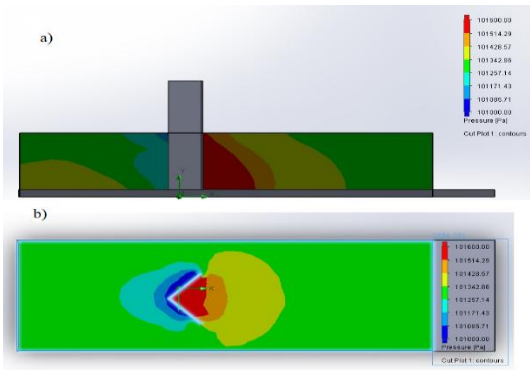

Figure 1. Computer modeling of turbulence zones around selected optimal obstacle. a) side view; b) top view

Most studies regarding flow around different obstacles analyzes ways to make shock waves and turbulence zones as small as possible, but in this study idea is quite opposite.[2] To get required measurement information we need optimal obstacle shape that would create bigger wave in front of it at lower flow velocities. To do that, author performed computer modelling of a flow around obstacles of different shapes, that were both technological and easy to produce as well as create bigger turbulence zones, waves and vortexes around them. Four different obstacles were checked: cylinder, square, triangle, but optimal one was an obstacle shaped like 90-degree construction frame with the corner pointing in the direction of the flow. Modelling results are shown on the fig. 1.

Experiment was performed in rectangular-shaped channel with selected obstacle semi-immersed in it. Measurements were performed with flow velocity changing from 0.21 m/s to 0.55 m/s

that is usual values for plain rivers. With flow velocity increase author observed turbulence zones increase as well as growing height of the wave in front of the obstacle. Experiment results showed dependency between flow velocity and a height of a wave in front of an obstacle that can be described but the equation: $y = 48.29x^3 - 56.552x^2 + 35.419x - 4.6681$ and that is shown on the fig. 2.

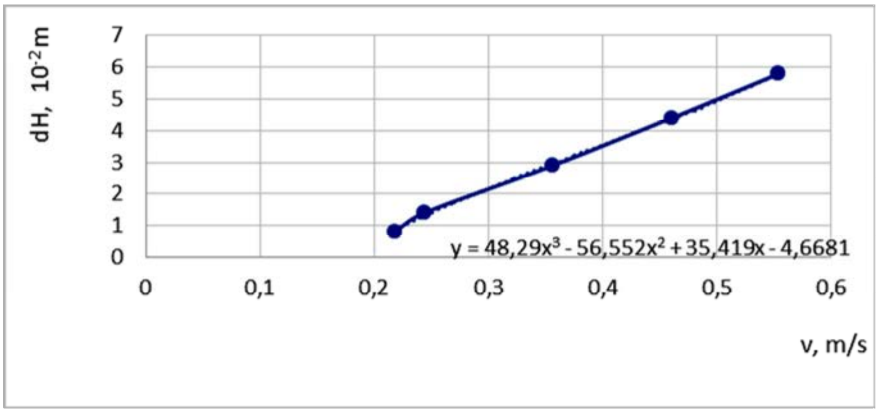

Figure 2. Approximated dependency between the height of a wave in front of an obstacle and flow velocity.

Due to the fact that suggested method uses video- and photo- shooting modules, web-camera was placed in different configurations around the obstacle to perform wave height measurements. Image processing was organized using open-source OpenCV libraries to utilize threshold filter functionality. Image is converted from RGB color scheme to HSV, and later filtered according to the measuring environment. Settings of the threshold filter can be changed manually due to the fact of different lighting and water color in the river at different time. Results shown on fig. 3.

Figure 3. A frame of the video- recording of the flow in front of an obstacle. a – original image. B – filtered image.

To provide constant and remote monitoring, author created measuring complex using Raspberry Pi 3B microcomputer unit. System consists of web-SCADA system that has server part in the complex and client requires only a device with Internet-access and browser to perform measurements and monitoring. Web-, FTP-, SSH servers provide tools not only for monitoring and measurements but reconfiguring the device at any time. Following research is planned to perform not only flow velocity but flow rate measurements with automatic measurements of channel geometry and shape.

References

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