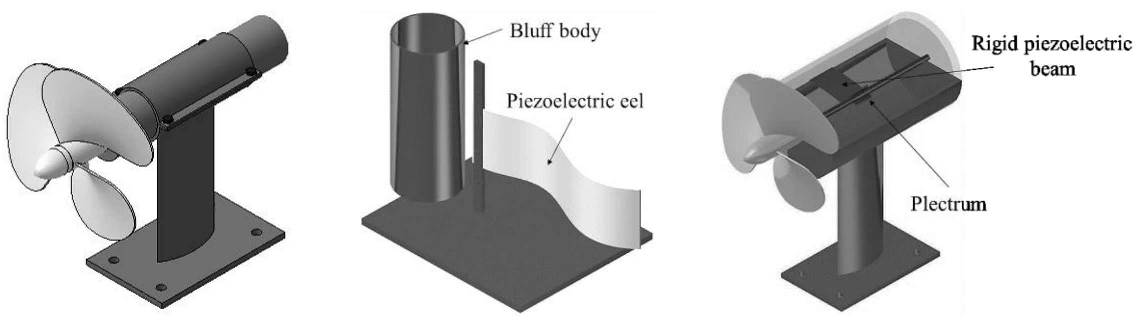
This research has been fully supported by the EU FP7 ICT-2009.9.1 project no. 269985.

GOLDFISH – DETECTION OF WATERCOURSE CONTAMINATION IN DEVELOPING COUNTRIES USING SENSOR NETWORKS – ENLARGED

Project summary

There is an evident need for monitoring pollutants and/or other environmental conditions in river flows via wireless sensor networks. In a typical wireless sensor network topography, a series of sensor nodes is to be deployed in the environment, all wirelessly connected to each other and/or their gateways. The Faculty of Engineering of the University of Rijeka, Croatia, together with 11 partnering institutions from the academic and the industrial sectors from Austria, Bolivia, Columbia, Croatia, France, Poland, Slovakia, Sweden and Vietnam, worked on this particular goal in the frame of the EU FP7 research project "GOLDFISH - Detection of Watercourse Contamination in Developing Countries using Sensor Networks - Enlarged". The project was worth about 2.6 million Euros, of which about 150’000 are dedicated to the activities of the Faculty of Engineering of Rijeka. In the course of the work on the GOLDFISH project, advanced computing communication tools have been successfully developed and tested in wireless networks of innovative self-cleaning bio-chemical sensors. The topography of sensors’ disposition was optimized. In particular, the Faculty of Engineering of Rijeka (RITEH) team has investigated the possibility to use three different small-scale river flow energy harvesting principles to power the foreseen sensor nodes: a miniaturized underwater turbine, a so-called ‘piezoelectric eel’ and a hybrid turbine solution coupled with a rigid piezoelectric beam. Thorough modelling and calculations were performed to optimize the design of the foreseen harvesting devices. The first two concepts were then successfully validated experimentally in laboratory as well as in real river conditions (Rječina, Croatia). The miniaturized hydro-generator was then inserted into the wireless sensor node system and its functionality was confirmed (Lievec, Poland). A suitable energy management electronics was also successfully developed and tested in real operation. The developed hydro-generator and its energy management electronics were finally embedded into the complete configuration of the wireless system aimed at tracking pollution in remote watercourses using sensor network technology, and successfully tested in the Coello river in Colombia.



(a) (b) (c)

Figure 1: Principles of considered energy harvesting solutions: hydro-generator (a), piezoelectric eel (b) and ‘plucked’ piezoelectric beam (c).

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Introduction

River courses play a vital role in preserving unpolluted ecosystems. On the other hand, network nodes can be employed to assess different values in the environment such as ambient temperature, pressure or humidity or even the concentrations of certain pollutants. With this motivation, the GOLDFISH project employed European ICT research capabilities for designing, manufacturing, validating and operating technological means for tracking pollution in remote rivers using sensor network technology. The sensor network is hence composed of sensor clusters located underwater in watercourses and gateways on the riverbank with long-distance communication links to the central management and monitoring station. In particular, in the case of large networks, when sensor nodes are placed in hardly accessible locations, energy harvesting can be a viable powering solution for the sensor nodes. The possibility to use three different small-scale river flow energy harvesting principles, depicted in Figure 1, was studied in the GOLFISH project by the RITEH team.

Autonomous solutions for powering wireless sensor nodes in rivers

Two energy harvesting concepts, based on powering the sensor clusters by using the river flow energy itself – that of a miniaturized hydro-generator (Fig. 1a) and that of a “piezoelectric eel” (Fig 1b), proposed in the GOLDFISH Description of Work (DoW), were successfully developed by the RITEH team. Analytical and numerical modelling and calculations were performed in this frame to optimize the design of the foreseen harvesting devices. A third (hybrid) concept (Fig. 1c), not initially described in the DoW, and that resulted from a new idea developed during the project, was theoretically described and simulated via a Finite Element Modelling (FEM) software. The first two concepts were subsequently successfully validated experimentally in a flow channel as well as in real river conditions. The miniaturized hydro-generator was then embedded into the wireless sensor node system and its functionality was confirmed. A suitable energy management electronics was also successfully developed and tested in real operation.

Conclusion

In the final cluster configuration the measurement and controller boards were set to collect the data every 15 s for one second; the GSM module, communicating once every hour with the gateway, needs ~ 2 min to transmit the data. All laboratory and river experiments confirm that the sensors, as well as the measurement and controller boards, can be successfully powered by the proposed innovative miniaturized hydro-generator harvester for the hence defined working periods without using a battery, accomplishing thus the main goal of the RITEH team. In fact, the final experiments in the Coello river, Ibague, Colombia, have proven that the hydro-generator with its management electronics can provide the power needed for the sensor cluster – after connecting the harvester and deploying the node into the river, the GSM transmission were therefore successfully performed! Moreover, a complex numerical model of the piezoelectric eel was built, which allowed an optimization of the device in order to obtain maximal power output efficiencies. Power levels that can be generated were experimentally assessed, which was not reported so far in available literature. Experiments with piezoelectric eels showed that a network (“farm”) of several eel harvesters should be used to successfully power the foreseen loads. The results of the project were successfully disseminated in international scientific peers’ fora as well as to civil society and broader audience stakeholders.