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BIOMIMETIC APPROACH TO ACTIVE WIRELESS ENDOSCOPY

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Introduction

In the VECTOR project a system for active wireless endoscopy has been developed that uses a magnetic capsule which is driven indirectly by moving a permanent magnet with a robot arm. One of the main problems is the controlled positioning of the capsule and moving it smoothly through the colon. Although a sophisticated sensor feedback control allows for compensating undesired movements and stabilization of the endoscope, experimental investigations revealed the necessity of further optimization of the endoscope design. As the interaction between the wireless endoscope and the biological tissue is decisive for the system performance, we considered biomimetics as an optimization method. Biomimetics take a close look on nature and biological systems to get inspirations for technological problems or vice versa.

Theory

We conducted a biomimetic research using the following process: To find applicable biological role models the operating principle of the capsule was analyzed and allometric rules set up. In a second step we performed a bio-screening in which analogies between biological organisms and the capsule were drawn. Analogy parameters were: A) environment and habitat, B) morphology (shape, surface and material) and C) movement (controllability, stability and maneuverability). We took a closer look on the hydrodynamics of whales, the morphology of rigid-bodied invertebrates and organisms living in tubes. Evaluation showed that not all role models were suited for an optimization of the capsule. In a more intuitive, design research, promising concepts were refined. Our focus was on implementing fluke-like control surfaces, use of flexible, skin-like materials, spine-like arrangement of the magnets inside and structuring the outside surface of the capsule.

Experiments

According to the concepts prototypes were built. We performed maneuver tests in a water-filled aquarium covered by a pig´s colon as well as in-vivo experiments. We compared bio-inspired prototypes with the conventional capsules and evaluated the potential optimization approaches.

Discussion

Biomimetics offers a broad spectrum of ideas to tailor the performance of active wireless endoscopes. Although a strict biomimetic transfer was not possible, we could demonstrate that the biomimetic approach inspires with a broad spectrum of techniques worth exploiting for this application.