The STIFF-FLOP (STIFFness controllable Flexible & Learnable manipulator for surgical OPerations) project started at the beginning of the year 2012 after successful contract negotiations with the European Commission. The Commission is providing € 7.35 Mio funding over 4 years.

STIFF-FLOP focuses on Challenge 2 - Cognitive systems and robotics.

STIFF-FLOP will address a number of scientific and technological challenges. In minimally invasive surgery, tools go through narrow openings and manipulate soft organs that can move, deform, or change stiffness. There are limitations on modern laparoscopic and robot-assisted surgical systems due to restricted access through Trocar ports, lack of haptic feedback, and difficulties with rigid robot tools operating inside a confined space filled with organs. Also, many control algorithms suffer from stability problems in the presence of unexpected conditions. Yet biological “manipulators”, like the octopus arm and the elephant trunk, can manipulate objects while controlling the stiffness of selected body parts and being inherently compliant when interacting with objects.

The project aims at overcoming shortcomings of existing robotic systems for minimally invasive surgery (MIS) by creating a soft robotic arm that can squeeze through a standard 12mm diameter Trocar-port, reconfigure itself and stiffen by hydrostatic actuation to perform compliant force control tasks while facing unexpected situations. STIFF-FLOP will apply a holistic approach addressing the complete robot system and studying the following research questions: design and fabrication of a soft manipulation and grasping device, distributed sensing, biologically inspired actuation and control architectures, learning and developing cognitive abilities through interaction with a human instructor and manipulation of soft objects in complex and uncertain environments.

Departing from the traditional robotic manipulation concepts that rely on fixed stiffness distributions, the STIFF-FLOP project takes inspiration from biological “manipulation and actuation” principles as they are, for example, found in the octopus who can turn its limbs from a completely soft state into a state of precise and, if needed, powerful articulation (see Figure 1) – an approach that combines advantages associated with both soft and hard systems by selectively controlling the stiffness of various parts of the body depending on the task requirements. Tightly integrating the input from established experts in biology, cognitive sciences, robotics, sensing and medical sciences, this project aims to overcome the drawbacks of current robotic manipulation concepts and to move into a new era for flexible robotics with great promise for many applications areas including minimally invasive surgery. Although we expect this field to bring new challenges when exploring the behaviours of such “stiff-flop” manipulators and how they interact dynamically with their environment, there are many advantages supporting the research in the development of STIFF-FLOP manipulator.

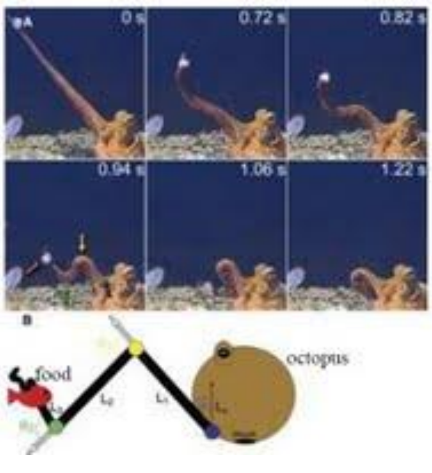

Figure 1: Octopus arm kinematics

With the aim of creating an embodiment of an artificial, flexible manipulation device modelled after the octopus limb, the STIFF-FLOP project will develop a new design approach to soft robotic manipulators whose physical morphology and control policies will adapt continuously in order to maintain an optimal symbiosis with uncertain environments and unpredictable task constraints in collaboration with a human operator in applications such as minimally invasive surgery. It is widely argued that cognition is an emerging property of physical and sensory interactions with the environment rather than something that can be programmed. Here we take the view that the uncertainty or stochasticity of the environment itself is an important architect of internal cognition that effectively organizes the body to maintain stable interactions with the real world. We believe that our approach is novel and will lay the foundation for robotic cognitive systems that can creatively face the uncertainty in the real world by allowing the uncertainty itself to drive the synthesis of cognition that can in turn control the agile body to co-exist with the uncertain world in a meaningful manner.

With the support of the European Association for Endoscopic Surgery (EAES) and three internationally-leading medical institutes (Guy's Hospital London, University of Turin, St Thomas Hospital London), we will test the soft arm in a minimally invasive robotic surgery application to demonstrate its feasibility.