spirits

SPIRITS

Smart Printed Interactive Robots for Interventional Therapy and Surgery
2017-2020

Final Executive Summary

Dépasser les frontières :
projet après projet
Der Oberrhein wächst zusammen,
mit jedem Projekt

Fonds européen de développement régional (FEDER)
Europäischer Fonds für regionale Entwicklung (EFRE)

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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Foreword

The SPIRITS project started in 2017. In three years, the project consortium has elaborated a set of new technologies for the growing field of image-guided radiology and surgery. 3D-printing techniques, actuation solutions, sensors and transducers have been developed and tested with joint work of partners and associate partners. Thanks to the support of co-financing partners, our tri-national consortium was able to develop new solutions for assistance to biopsy procedures. In addition, dissemination of the project results was achieved in the Upper Rhine area and at an international level. In this executive summary, we introduce some of the main achievements and give a focus on the major contributions obtained in this three-year period.

Le projet SPIRITS a débuté en 2017. En trois ans, le consortium du projet a élaboré un ensemble de nouvelles technologies pour le domaine en croissance de la radiologie et de la chirurgie guidées par l'image. Des techniques d'impression 3D, des solutions d'actionnement, des capteurs et des transducteurs ont été développés et testés grâce au travail conjoint des partenaires et des partenaires associés. Grâce au soutien des partenaires cofinanceurs, notre consortium trinational a pu développer de nouvelles solutions d'assistance aux procédures de biopsie. En outre, les résultats obtenus ont été disséminés dans la région du Rhin supérieur et au niveau international. Dans ce résumé, nous présentons quelques-unes des principales réalisations et mettons l'accent sur les contributions majeures obtenues au cours de cette période de trois ans.

Das SPIRITS-Projekt begann 2017. In drei Jahren hat das Projektkonsortium eine Reihe neuer Technologien für den wachsenden Bereich der bildgestützten Radiologie und Chirurgie entwickelt. In gemeinsamer Arbeit der Partner und assoziierten Partner wurden 3D-Drucktechniken, Antriebslösungen, Sensoren und Wandler entwickelt und getestet. Dank der Unterstützung von Kofinanzierungspartnern konnte unser trinationales Konsortium neue Lösungen zur Unterstützung von Biopsieverfahren entwickeln. Darüber hinaus wurde die Verbreitung der Projektergebnisse im Oberrheingebiet und auf internationaler Ebene erreicht. In dieser Zusammenfassung stellen wir einige der wichtigsten Errungenschaften vor und konzentrieren uns auf die wichtigsten Beiträge, die in diesem 3-Jahres-Zeitraum erzielt wurden.

Project Outline & Main Achievements

The SPIRITS Interreg project aimed at developing an innovative robotics by 3D-printing for interventional radiology and image guided surgery.

The project gathered five partners: INSA Strasbourg (INSA, Lead Partner), Hochschule Furtwangen (HFU), Medizinische Fakultät Mannheim der Universität Heidelberg (UMM), Fachhochschule Nordwestschweiz (FHNW) and Ecole polytechnique fédérale de Lausanne (EPFL). Eight associate partners were part of the consortium: Universität Mainz, Biovalley France, Axilum Robotics, SAES Getters S.p.a., Help Tech GmbH, Sensoptic SA, iSYS Medizintechnik GmbH, Kantonsspital Baselland.

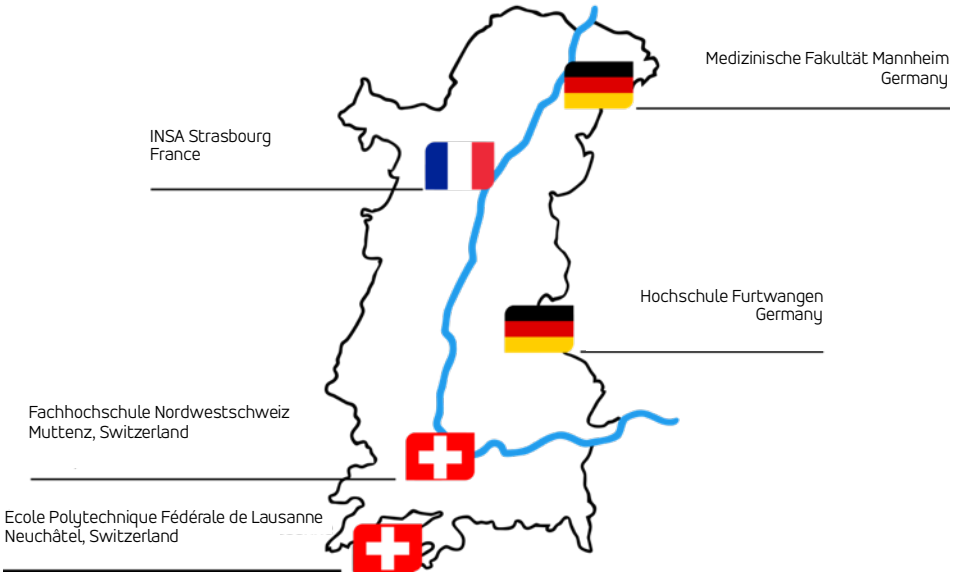
The SPIRITS project was launched as part of the Science Offensive initiative. It was supported by the Région Grand Est, Land Baden-Württemberg, Land Rheinland-Pfalz, Cantons Baselstadt, Basellandschaft, Aargau, Swiss Confederation, Baur SA and by the program INTERREG Upper Rhine from the European Regional Development Fund (ERDF) - to the tune of 436 201 €. The three-year project started in April '17 with a total budget of 1.67 M€.

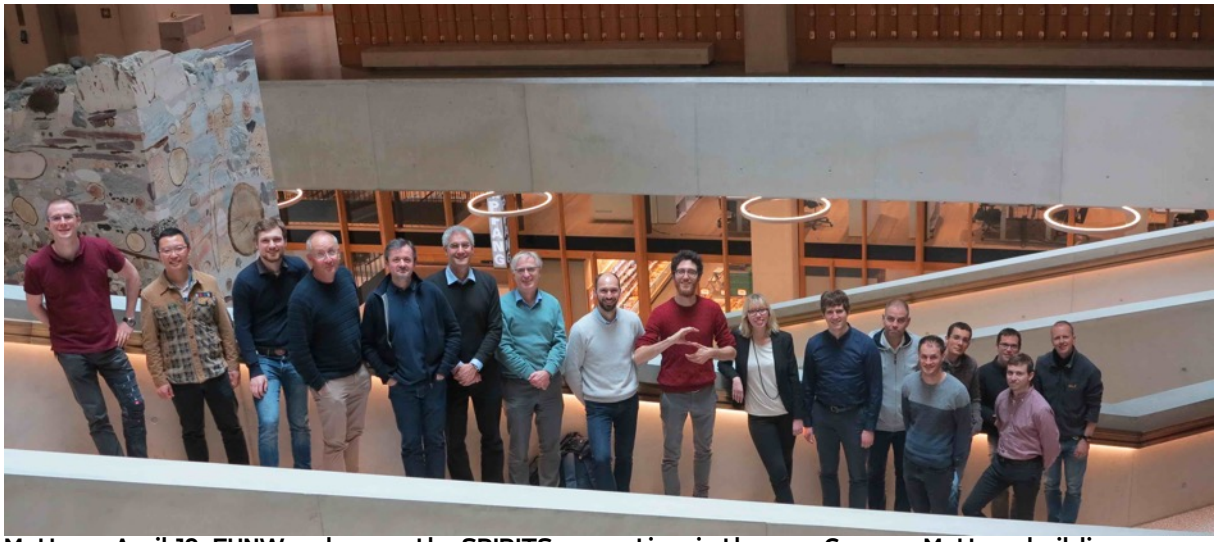
Medical image is being used more and more for guidance of medical tasks in radiology and surgery. Image-guided surgery is seeing strong development for a better management of pathologies. Despite the difficult access to the patient and the risk associated with exposure to X-rays from imaging devices for physicians, targeted accuracy remains very high. The SPIRITS transnational consortium developed effective research collaborations leading to several technical innovations and an innovative device for image-guided procedures. The limits of 3D-printing for titanium and nitinol medical parts have been pushed by FHNW with proofs of concept investigated in collaboration with INSA. HFU introduced new DEAP-based tactile transducers and demonstrated in collaboration with EPFL and INSA the interest of tactile feedback during surgical needle manipulation. UMM and INSA jointly developed new hydraulic actuation components and techniques for the medical field. EPFL designed and tested surgical needles with embedded force sensors at the tip, and also introduced new concepts of surgical needles with INSA. All partners thus contributed to the elaboration of a new device for safe manipulation of surgical needles in image-guided therapies.

For each work package, interactions with associate partners helped in the development of scientific activities and dissemination actions. The intensive efforts for dissemination and communication of the consortium allowed the consortium to show companies the interest of these technologies and components: 25 companies joined the workshops the consortium organized. 150 people attended the SPIRITS events. The project was presented in 15 events, and the project website was accessed more than 24'000 times during the course of the project. Dissemination toward physicians and scientists was achieved with participation in 22 conferences and 4 journal publications.

Focus #1 – Team Work

General meetings have been organized between the partners on the different institutions. These were opportunities to foster collaboration within the research consortium, with exchanges during on-site mutual visits of technological platforms. Several meetings with associate partners were organized in addition for specific technical exchanges. After three years, fifty per cent of the work presented in conferences is joint work involving at least two partners, which shows the interest and reality of this team work.

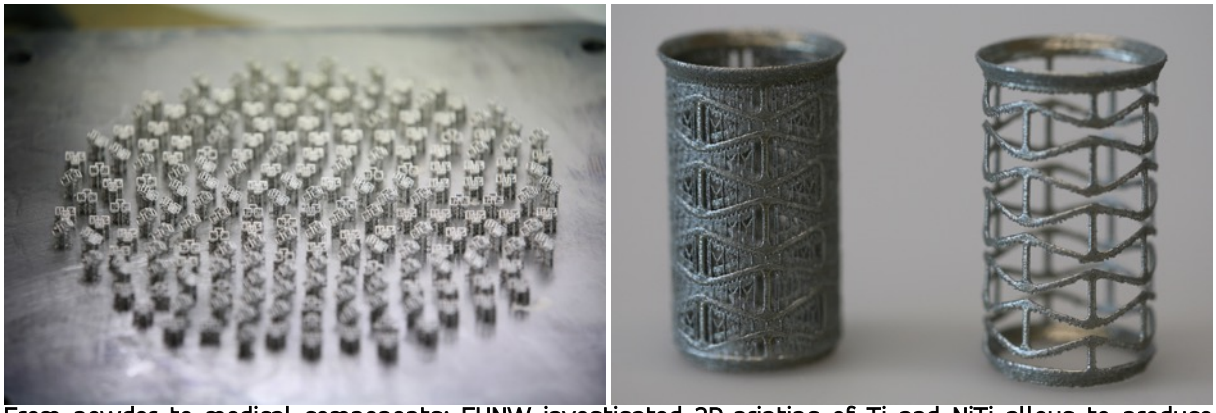




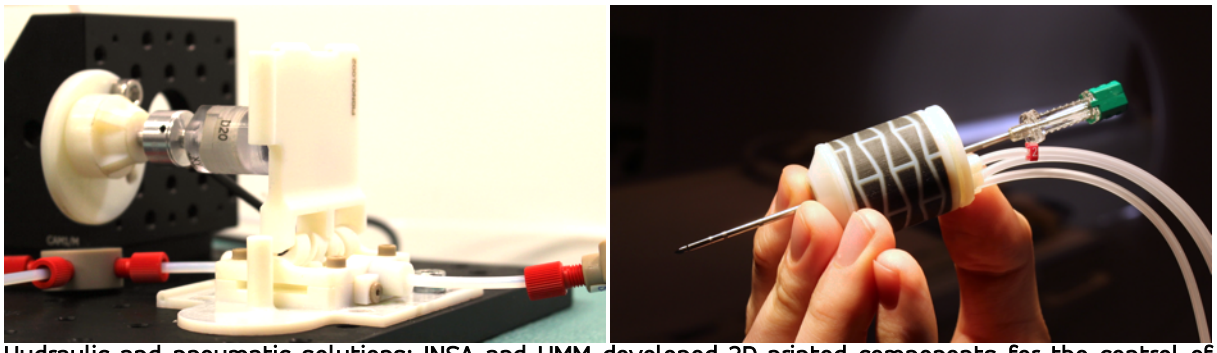
Muttenz, April 19: FHNW welcomes the SPIRITS consortium in the new Campus Muttenz building.

Focus #2 – Development of robotic components

Robot design in medical context is not only challenging because of the lack of space in the operating room but also because of the required compatibility with different imaging devices. INSA, FHNW and UMM investigated new designs obtained using 3D-printing.
Significant progress has been made in the manufacturing of titanium and nitinol structures thanks to advanced manufacturing strategies. Actuation solutions for the control of surgical needles were then developed. Pneumatic and hydraulic actuators have been created, in particular using the freedom of shape of 3D-printing to introduce innovative piston designs.
In the end, several demonstrators using passive or active hydraulic technologies have been set up to validate the capacity to produce robotic components and systems, which are compatible with the stringent medical environment.



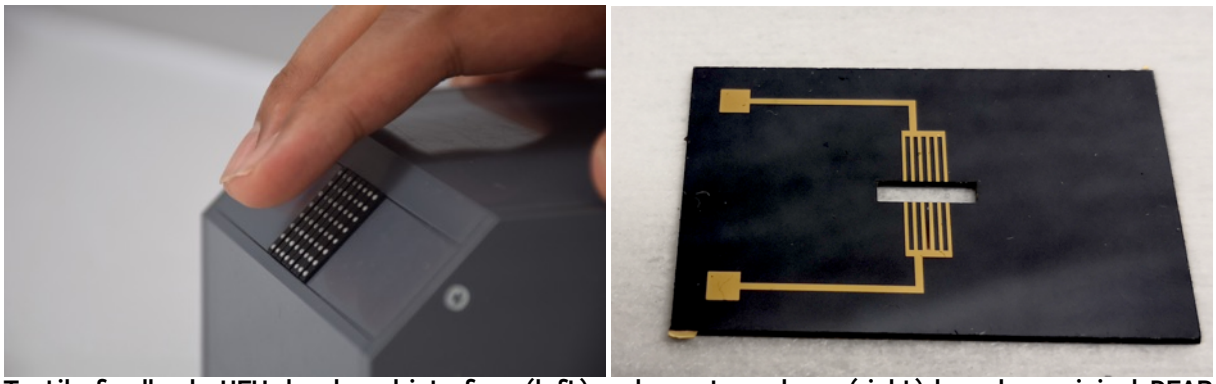
From powder to medical components: FHNW investigated 3D-printing of Ti and NiTi alloys to produce components such as fluidic actuators.



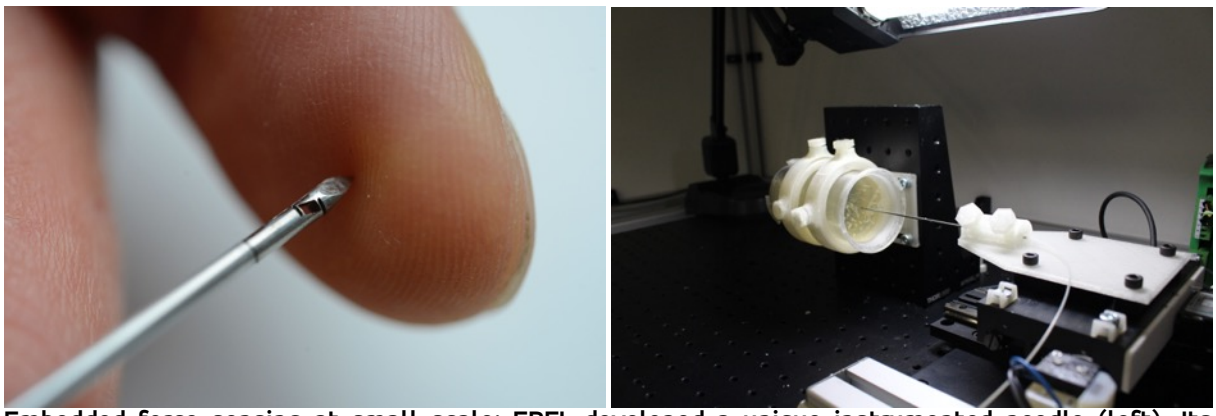
Hydraulic and pneumatic solutions: INSA and UMM developed 3D-printed components for the control of translational and rotational motions as exploited in robotic solutions.

Focus #3 – Design of sensor and transducers

Providing information to the radiologist beyond the visible with force-related events is crucial. Research work was focused on two aspects. First, technologies for tactile feedback have been developed. New transducer designs have been investigated by HFU, combining simulation and prototyping. The proposed DEAP-based solutions are based on cooperative electrodes which enhances the number of possible feedbacks to the user.
Second, EPFL successfully integrated force sensor at the tip of the biopsy needle, making it possible to sense subtle events such as the puncture of organs. The surgical tool performance was coupled with tactile feedback thanks to the design of a master interface by HFU and tested at INSA. The efficiency of tactile feedback could be observed in laboratory conditions.



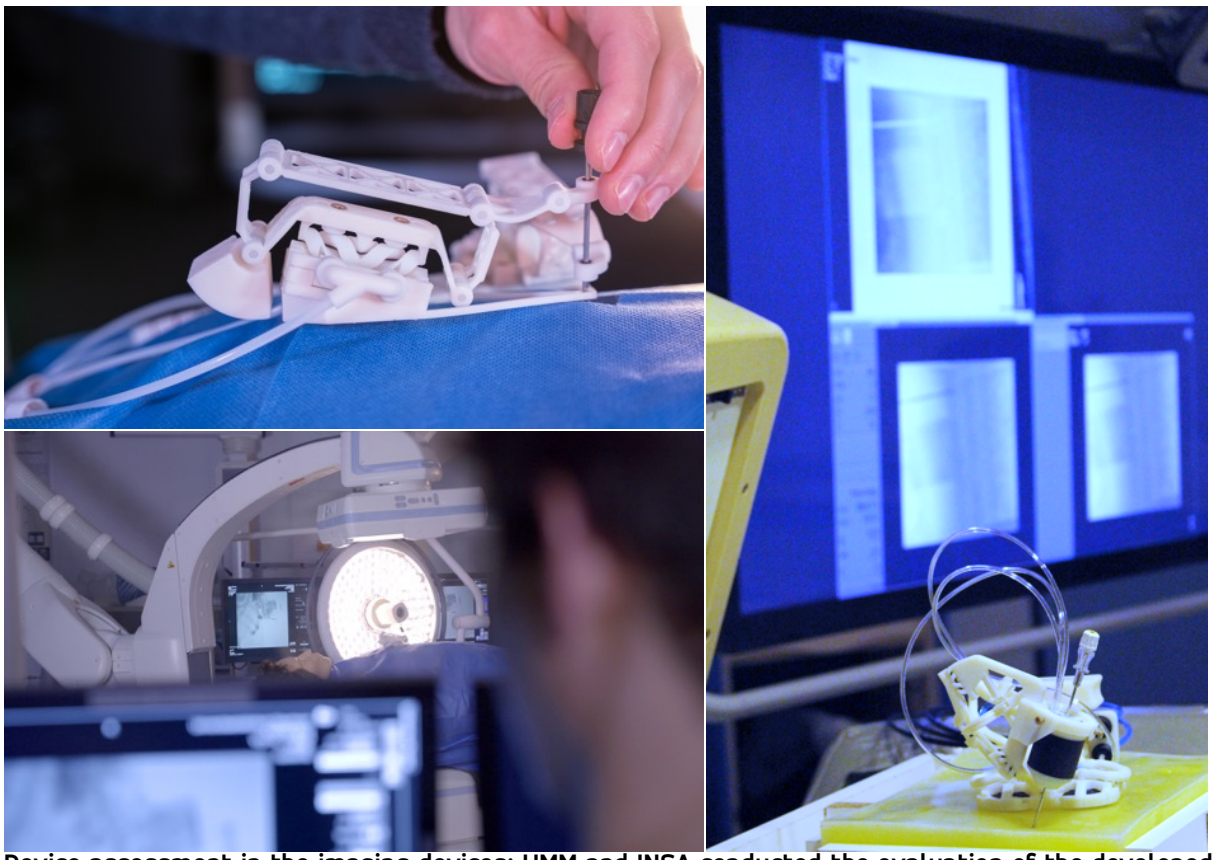
Tactile feedback: HFU developed interface (left) and new transducer (right) based on original DEAP design using cooperative electrodes.



Embedded force sensing at small scale: EPFL developed a unique instrumented needle (left). Its interest in combination with tactile feedback was shown jointly with INSA and HFU (right).

Focus #4 – Device development and evaluation

The SPIRITS approach of image-guided procedures consists in relying on assistance tools provided in the imaging devices. This implies that it is possible to produce small-size devices that fit in the imaging devices. The quality of medical images also needs to be maintained to avoid any confusion during the procedure. Several prototypes have been produced and tested accordingly. Compatibility with imaging X-Ray and MRI devices was investigated by UMM and INSA. Impact of robotics in terms of procedure duration and X-ray exposure was also analyzed in collaboration with the University Hospital of Strasbourg. Feedback from radiologists was collected throughout the duration of the project. The results are very encouraging in terms of safety improvement and ease of use, confirming the potential benefit associated with the use of the approach developed in the framework of the SPIRITS project.



Device assessment in the imaging devices: UMM and INSA conducted the evaluation of the developed devices in terms of image compatibility and also safety improvement for physician.

Focus #5 – Dissemination & Communication

A part of the SPIRITS project was also dedicated to the development and transfer of medical technologies. Strong efforts were made to present the work achieved within the consortium at national and international events targeting both the scientific community and companies. The expertise of the consortium and its newest results were disseminated in regional events such as the MedicalMountains Innovation Forum Medical Technology or [MEET-THE-EXPERT]-implants conference. The project was also presented at international conferences and events like IEEE[1] ICRA[2] and EMBC[3] conferences or MEDICA trade fair, attracting over 120,000 visitors in November 2018. Two additional workshops have been organized in Strasbourg, welcoming thus over 25 companies to create new contacts.
The SPIRITS project being about health and improvement of surgical techniques, presenting the work to a wider audience was highly important for the project partners. Therefore, several communication actions aimed at making people aware of the ongoing efforts to improve healthcare services in the Upper Rhine region. The project was for instance part of the Fête de la Science in France in October 2018. Over 24,000 connections to the SPIRITS website (interreg-spirits.eu) have been recorded.

SPIRITS consortium co-organized with the Interreg project Nanotransmed and ECPM Strasbourg the HealthTech Innovation Forum in May 2019.

SPIRITS developments were presented at different scientific and industrial events: UMM was present at MEDICA trade fair (left), INSA at Surgetica 2017 conference (right).

[1] Institute of Electrical and Electronics Engineers (IEEE)
[2] International Conference on Robotics and Automation (ICRA)
[3] Engineering in Medicine and Biology Conference (EMBC)

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