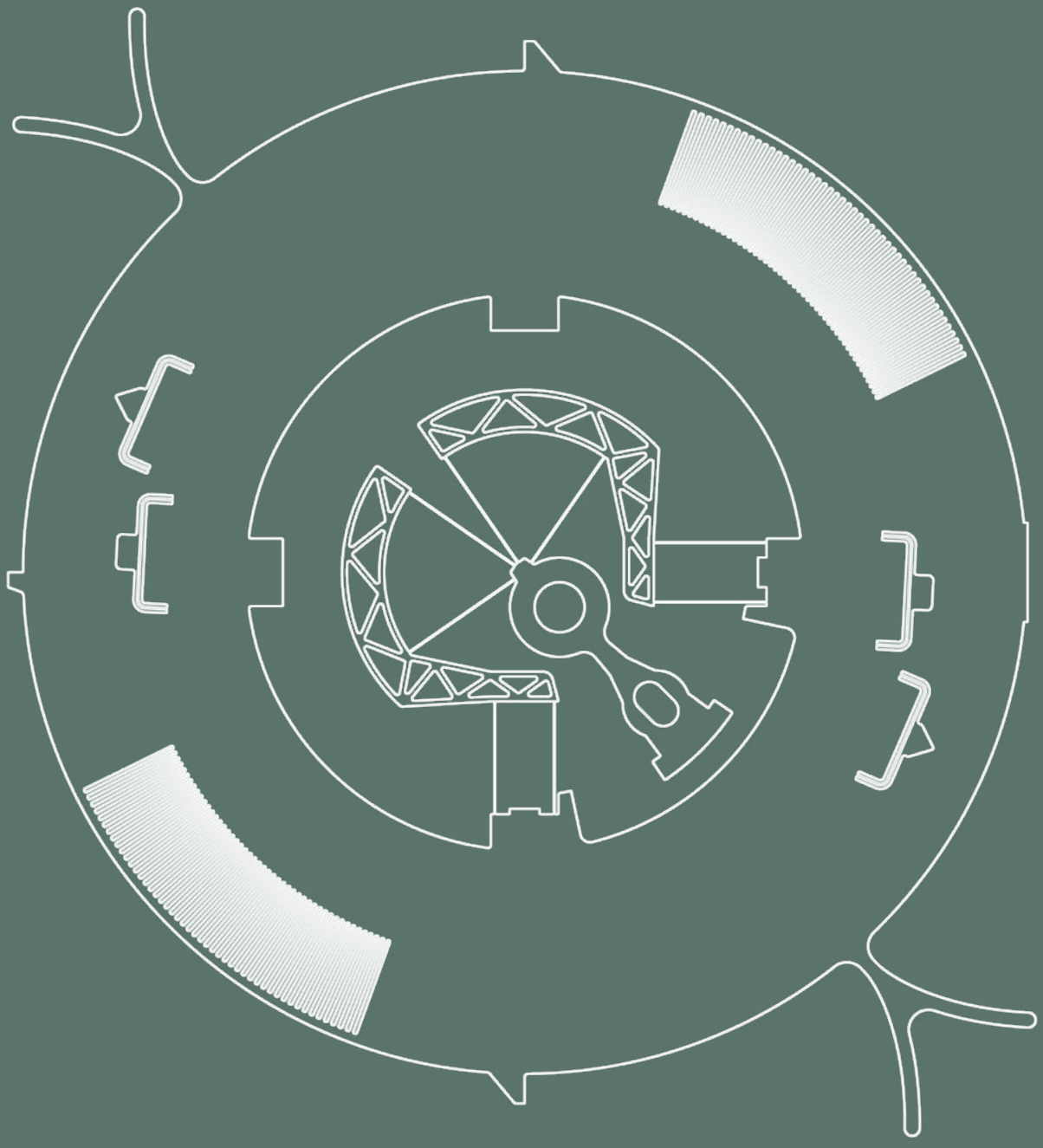
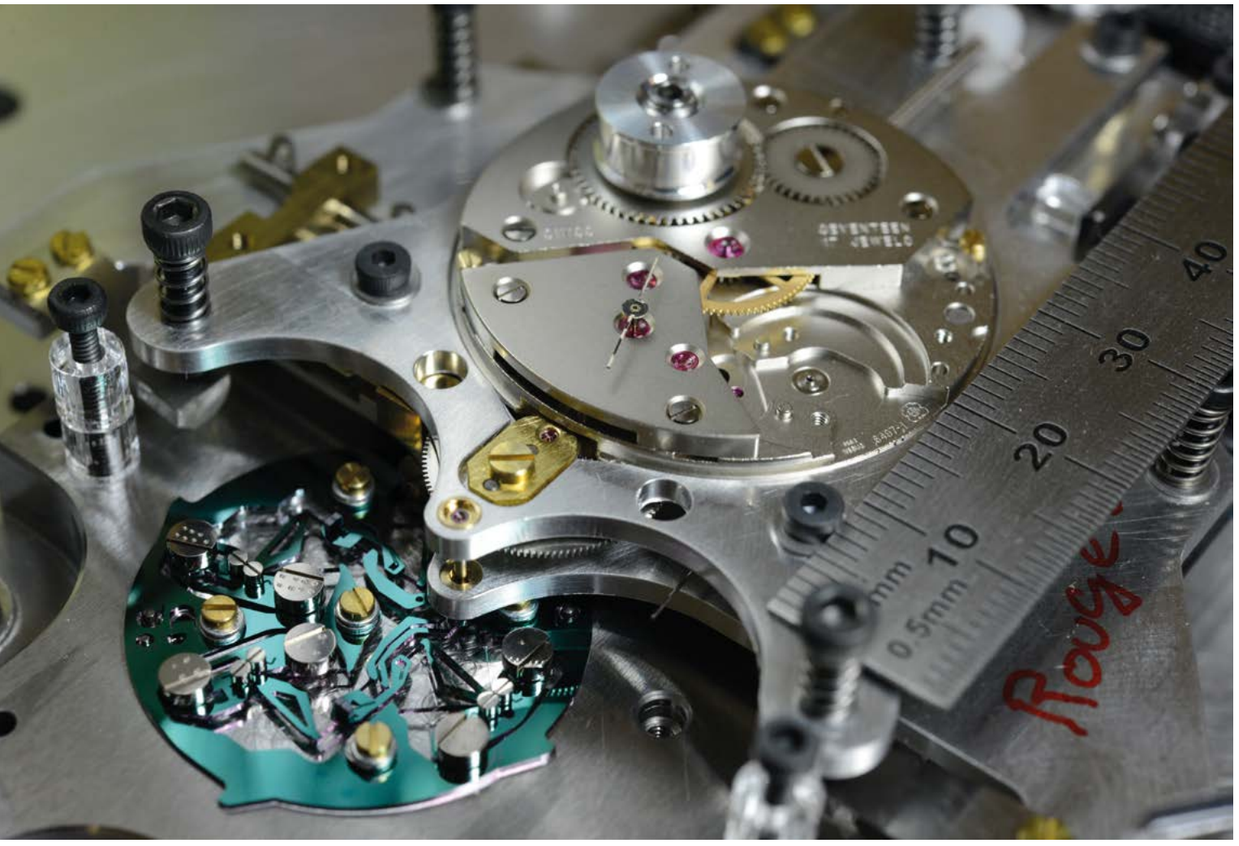
Patek Philippe Chair

Micromechanical and Horological Design Laboratory
INSTANT-LAB

Annual Report 2019 – 2020





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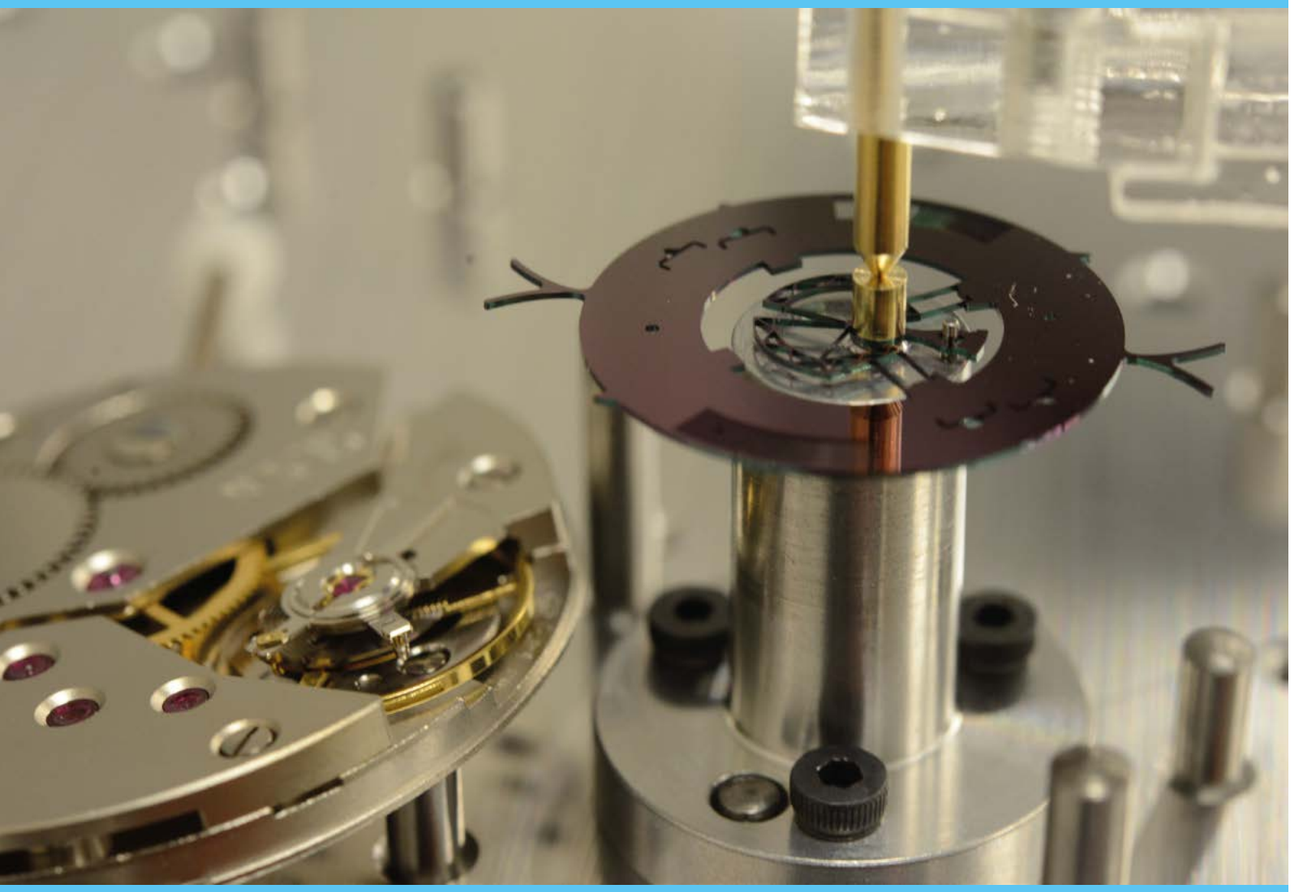
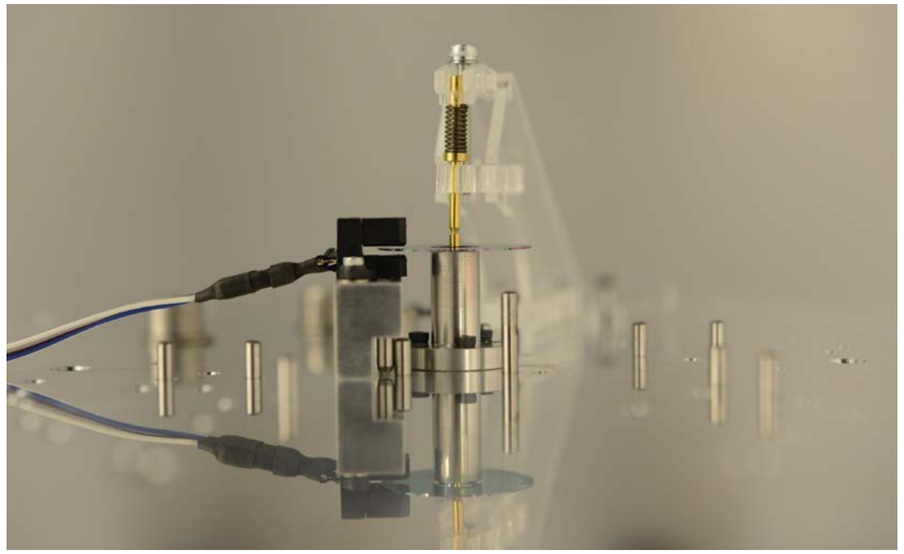


INTRODUCTION

In 2020, the Patek Philippe Chair in Micromechanical and Horological Design celebrated its eighth year. Over the 2019-2020 period, Instant-Lab had between fifteen and twenty collaborators. Currently the lab is composed of Professor Henein, two administrative assistants, two senior scientists, three postdoctoral scholars, one Ph.D. student, five scientific assistants and one technician. In addition, Instant-Lab has four external collaborators.
The laboratory specializes in creating new mechanisms featuring kinematic and technological innovation at the centimeter scale using a scientific approach inspired from mechanical design in fields such as classical horology, medtech and robotics. Current projects involve mechanical watchmaking and biomedical instrumentation, these fields being quite close, both technologically and in their industrial fabric. Beyond its academic mission to pursue excellence in fundamental research and teaching, the laboratory is also committed to establishing ties with the Swiss watchmaking industry and welcomes industrial collaboration with all Swiss watchmaking companies.

The lab team is also highly engaged in the development of novel approaches for the teaching of the engineering design to bachelor and master student. The pedagogical research activities are run in collaboration with the University of Neuchâtel and the University of Lausanne.



TEAM

Director

Prof. Simon Henein

Joëlle Banjac
Administrative assistant

Lysiane Bourquin
Administrative assistant

Post-Docs

Dr Roland Bitterli

Dr Susanne Martin

Dr Mohamed Zanaty

Dr Etienne Thalmann

Scientific Assistants

Lisa Bonnefoy

Thomas Fussinger

Marine Clogenson

Hubert Schneegans

Tristan Derbanne

Loïc Tissot-Daguette

Patrick Flückiger

Ph.D. Students

Sebastian Fifanski

Michal Smreczak
External

Technicians

Romain Gillet

Arnaud Maurel

External collaborators

Joëlle Valterio

Billy Nussbaumer

Begonia Tora

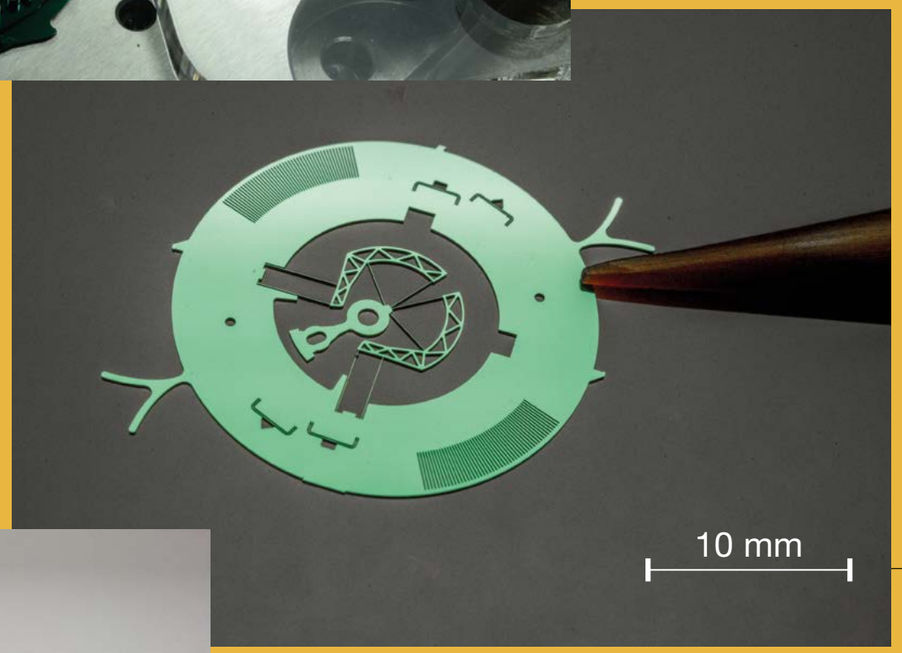
Olivier Chappuis

Senior Scientists

Dr Charles Baur

Dr Ilan Vardi

RESEARCH PROJECTS (part 1/3)



IsoSpring : Continuous mechanical time

Mechanical timekeeping began in the Middle Ages with the invention of the escapement. After the introduction of oscillators in the 17th century, mechanical clocks and watches continued to rely on this intermittent transmission. The IsoSpring project exploits ideas dating back to Isaac Newton to create a new time base which can be driven without an escapement. Instead, a crank drives the oscillator continuously, without the stop-and-go “ticking” of traditional mechanical clocks and watches. The crank mechanical transmission potentially leads to an increase in efficiency, while the high quality factor of the flexure-based oscillator opens the road for improved chronometric accuracy.

This project is based on a new family of oscillators and maintaining mechanisms patented by the EPFL.

Our first proof of concept in 2013 was followed by more precise time-bases. Our first prototype was built in 2016 and is on permanent display at the Neuchâtel City Hall. A second prototype using a spherical oscillator was exhibited at the International Museum of Horology, La Chaux-de-Fonds, as the showpiece of their exhibit of Neuchâteloise clocks in the Fall of 2017.

An industrial project was established in 2014 and successfully completed in 2017. This was followed up by a second industrial project completed in 2019.

Our current research is focused on miniaturizing to the watch scale.

Wattwins two-degree-of-freedom dynamically balanced oscillators etched in monocrystalline silicon. The smallest mechanism (bottom right) has a size which fits into a classical wrist-watch movement.

High quality factor oscillators for wrist watches

Current mechanical wrist watches have an oscillator consisting of a balance wheel mounted on jewelled bearings and a hair spring. The use of flexure bearings instead of traditional pivots leads to a significant increase in quality factor, i.e., reduced energy loss. As a result, power reserve can be significantly increased and chronometric precision can be improved thanks to reduced oscillator perturbation. However, these new oscillators are sensitive to gravity and have isochronism defects.

A major contribution of this project was the introduction of the concept of isochronism tuning which allows the oscillator to compensate for isochronism defects introduced by factors such as the escapement. This is a significant advance from the previous method of simply minimizing isochronism defect. Moreover, this was achieved while minimizing perturbation due to the orientation of the watch with respect to gravity.

This project was a successful industrial collaboration resulting in a Ph.D. thesis completed in June 2020.

Flexure-based balance wheel etched in monocrystalline silicon. This patented design is based on two Remote Centre Compliance pivots arranged such that their parasitic shifts cancel which minimises the effect of gravity on frequency.

Foucault pendulum properties of oscillators

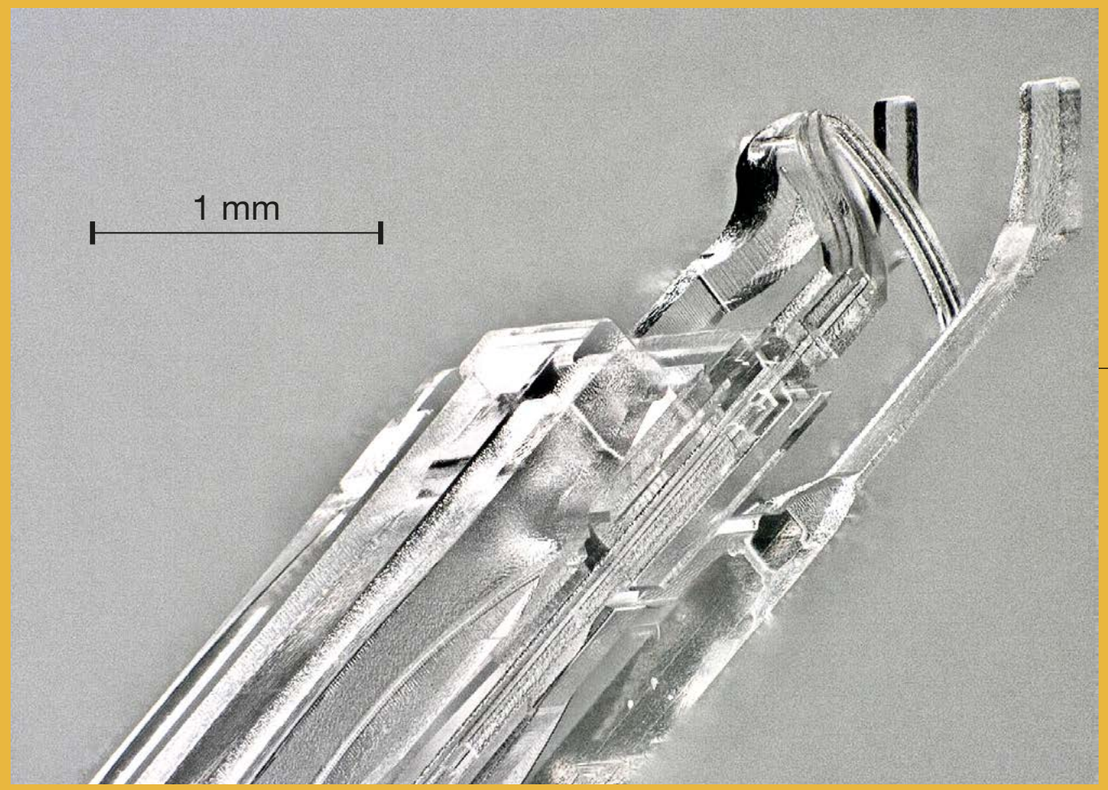
In 1851, Léon Foucault created a sensation with his pendulum providing a direct demonstration of the turning of the Earth. This simple device consists of a spherical pendulum whose mass is launched in a purely linear orbit. Following Mach’s principle of inertia, the mass will continue to oscillate in the same linear orbit with respect to absolute space. For an observer on the Earth, however, the plane of oscillation will precess. Conceptually speaking, Foucault constructed a very precise demonstrator showing that, when put on a rotating table, linear oscillations of a harmonic isotropic two-degree-of-freedom (2-DOF) oscillator, remain linear with respect to an inertial frame of reference.

This project consists of studying the Foucault property for a variety of 2-DOF oscillators. The first case considered was a spherical oscillator previously used as a time base for a precision clock. We showed the surprising result that the plane of oscillation does not remain constant with respect to absolute space, but follows the rotation table at one half its rotational speed. The analytical computation predicting this behaviour was validated by constructing a physical model, placing it on a rotating table and making accurate measurements. The results were published in Review of Scientific Instruments in 2020.

The Foucault phenomenon is disturbed by parasitic effects which increase as pendulum length decreases. For this reason museum demonstrators are usually more than 7 meters long. We designed an alternative 2-DOF oscillator based on flexures which we believe can display the Foucault phenomenon while small enough to be transportable and placed on a table. The design was presented at the IDETC international conference in August 2020.

Prototype spherical oscillator with new Foucault pendulum properties.

RESEARCH PROJECTS (part 2/3)



Programmable multistable energy storage mechanisms

This project introduces the concept of programmable multistable mechanism in which the number and position of stable states of a multistable mechanism can be modified. A complete qualitative analysis of a generic multistable mechanism, the T-shaped mechanism, was established using analytical tools based on Euler-Bernoulli beam theory. These results were validated numerically using Finite Element Analysis and experimentally using physical models. Applications include new surgical tools.
This project produced a number of publications including a 2018 Ph.D. thesis in our laboratory. The project is currently a collaboration with the Bertoldi Group, School of Engineering and Applied Sciences, Harvard University.

CTI Safe Puncture Optimized Tool (SPOT) for retinal vein cannulation

Retinal Vein Occlusion is a vascular disorder causing severe loss of vision. Retinal vein cannulation and injection of therapeutic agents in the affected vein is a promising treatment but the small size and fragility of retinal veins as well as the surgeon limited hand gesture precision and force perception makes this procedure too delicate for routine operations. The project aims at providing a compliant mechanical tool relying on a new programmable multistable mechanism to safely cannulate veins. This mechanism has the advantage that puncturing stroke and force can be predetermined with puncturing then independent of surgeon manipulation. The feasibility of this project was demonstrated by a prototype made by femto-laser printing, one of the first buckled mechanisms made in glass. This project is funded by FemtoPrint SA and the Commission for Technology and Innovation CTI (Switzerland) and run in collaboration with Pr. Th. Wolfensberger, Hôpital Ophtalmique Jules-Gonin, Lausanne.
The theory and results of this project were published in a medical journal in 2019.

Head and needle of the Safe Puncture Optimized Tool (SPOT) machined in glass by Femto Laser Printing.

Innotools

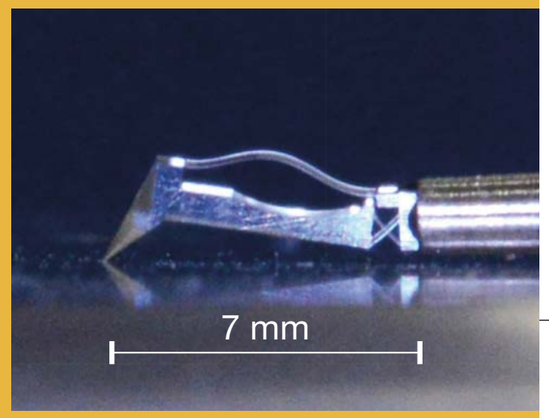
This project proposes a change to the MIS and RMIS tool paradigm. The goal is to develop Smart MIS/RMIS tools as stand-alone systems keeping their basic mechanical function (pinching, cutting, puncturing, palpating) while adding sensing functions at the tool-tip (kinesthetic and tactile sensing without trocar perturbation) and embedded mechanical systems (actuating, sampling). InnoTools will collect significant amounts of data which will be analysed in order to improve surgical procedures and develop superior prototypes for surgical planning, surgeon training and surgery assessment. The focus of this project is on ENT surgery and middle-ear measurement and assessment. The Innotools project is financed by a grant from Zeiss (Research IDEAS EPFL Program).

Tool for in-vivo stiffness measurement manufactured in fused silica (CAD view).

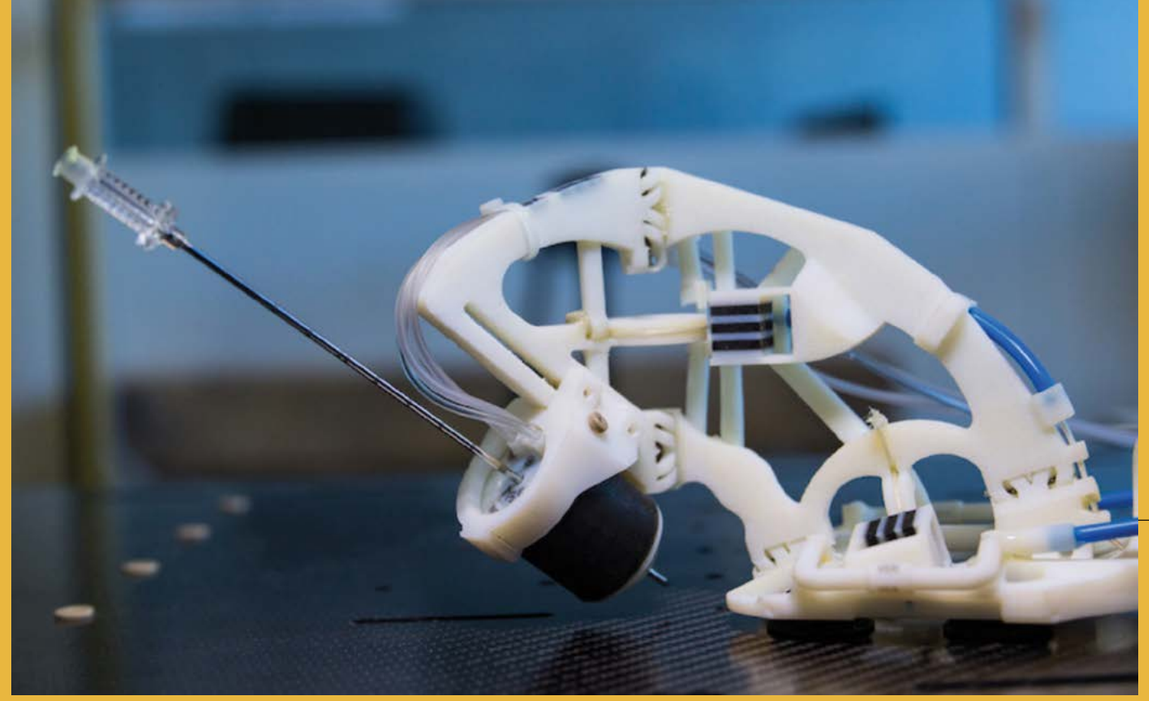
Clic-Clac : force sensing tool for middle-ear surgery

The aim of the project is to design and manufacture a miniature force sensing tool for middle-ear surgery. Currently, surgeons assess the mobility of the ossicle chain manually using conventional elongated hooks through the ear canal, rendering the outcome subjective and imprecise. Applied forces are of order 10 milli-Newtons (mN) therefore difficult to sense manually and requiring extensive surgical experience and skill. Depending on the estimated mobility, one or more ossicles are removed and replaced by miniature prostheses. Our proposed innovation consists of a standard tool where the tip is replaced by a flexible structure that bends at a specified force. The goal is to supply surgeons with a set of hooks having different triggering forces in order to allow them to determine at which force ossicles start moving, thereby providing an objective quantification of ossicle chain mobility. The project is in partnership with SENSOTPIC SA.

Tool for in-vivo stiffness measurement manufactured in fused silica.



RESEARCH PROJECTS (part 3/3)



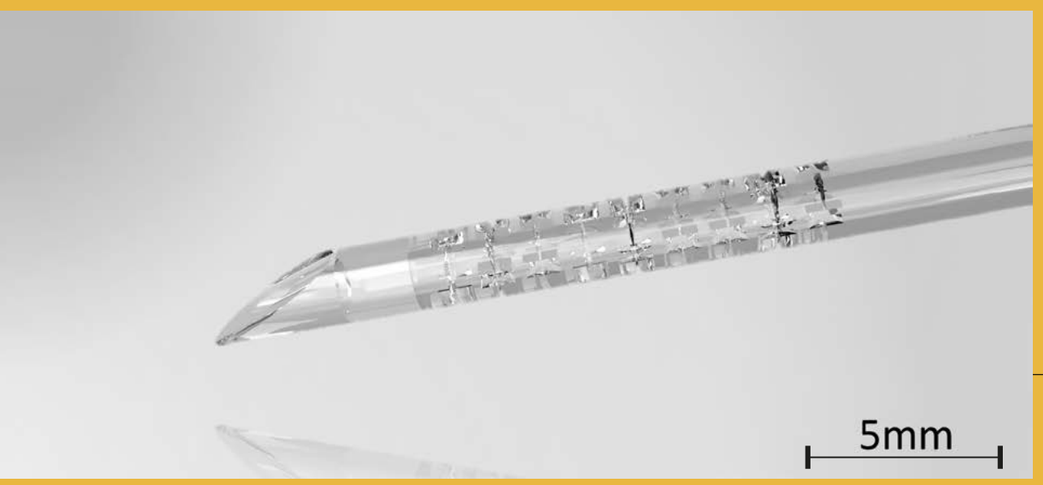
SPIRITS: Interactive intelligent robotics and 3D printing for surgery and interventional radiology

The SPIRITS (Simple Printed Interactive Robotics for Interventional Therapy and Surgery) project involves developing a robotic device for image-guided surgery and interventional radiology with a number of innovations, such as a tactile transducer, an intelligent needle, new 3D printing methods and new actuators and robots. This Interreg project is a collaboration between leading institutions: INSA Strasbourg, Hochschule Furtwangen, University Hospital Mannheim, Fachhochschule Nordwest-schweiz, EPFL.

MRI compatible active tool holder with 3D-printed polymer articulated structure and pneumatic actuators.

Steerable medical needle for accurate targeting of tissues and lesions: ARC (Aiguille à Raideur Contrôlée)

Surgical and diagnostic procedures such as biopsies are often carried out by means of percutaneous flexible devices such as flexible needles. The effectiveness of such devices depends on the ability to follow a controlled path during insertion inside human tissue. Millimeter-accuracy of the trajectory is crucial as the needle can approach vital organs as it reaches its target. The goal of the ARC project is to create a steerable needle using a passive mechanism. As opposed to the active mechanisms typically used, passive mechanisms rely on the reaction of body tissues to apply the force to produce the required bend of the needle. Our needle is composed of joints that can be stiffened or loosened at the handle, as pressure from tissues during insertion bends the needle to change its direction. Basically, instead of fighting tissue pressure, this pressure is used to correct the needle trajectory. The approach is based on flexure mechanisms. ARC is a joint INSA Strasbourg – EPFL project, financed by SATT Conectus.

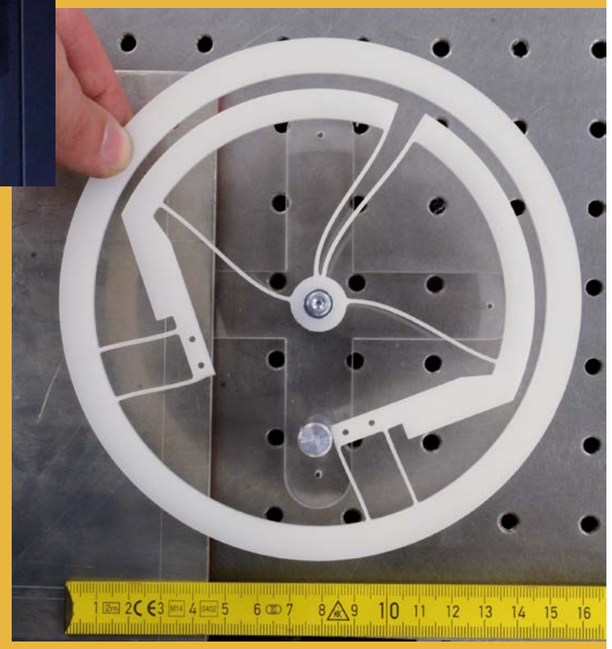


CAD view of a medical needle with adjustable bending stiffness for insertion trajectory steering.

FlexiGrip-SMA: flexure-based gripper with shape memory alloy actuators

The aim of the project is to design and implement new gripper kinematic solutions and to optimize actuation performed with SMA. Currently most of the grippers used for assembly and manipulation are actuated by electromechanical or pneumatical means. These approaches have severe limitations when the parts to be manipulated or their environment do not allow any contamination, are performed in explosive environments, requires high accuracy, high speed, etc. Mikron together with EPFL-LAI started to develop SMA actuation solutions to provide an alternative to conventional gripper actuators. The promising results showed that the impact of such innovative solution could be increased if the kinematics of the grippers no longer relies on conventional methods using moving parts showing frictions, requiring lubrication and having play. To develop monobloc flexure based grippers will suppress all these drawbacks while at the same time simplifying the assembly and providing easy scale up and down to adapt to specific user or task requirements.

Large scale mock-up of the FlexiGrip-SMA gripper.

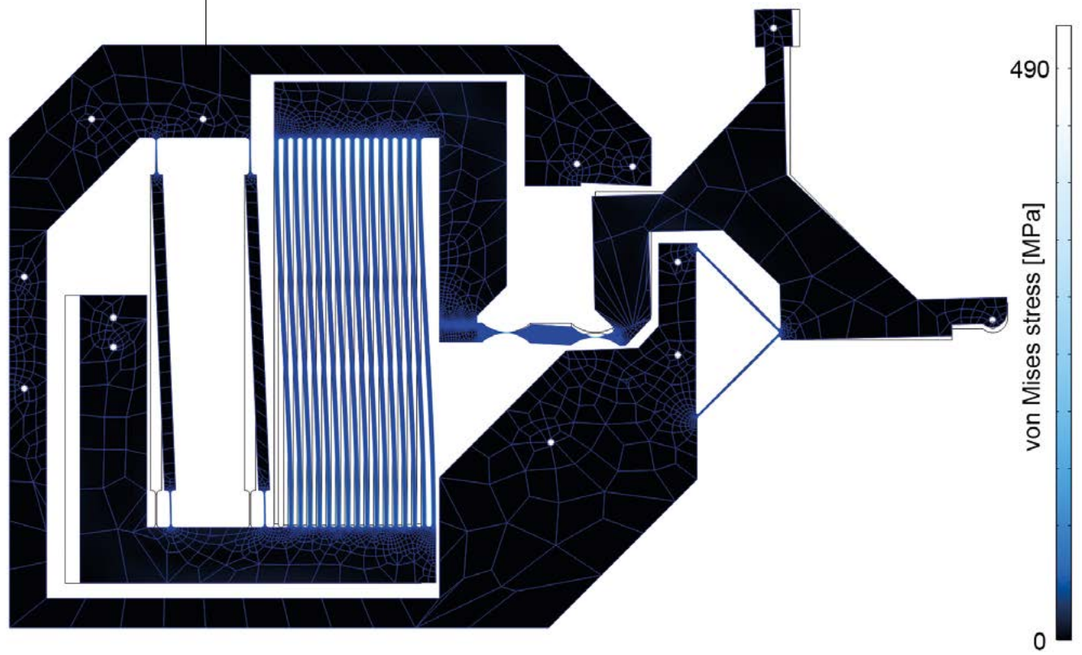


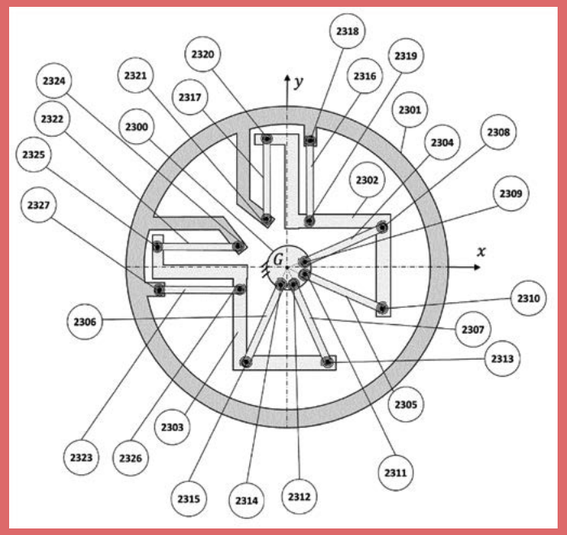
RESEARCH — Ph.D. THESES

Sebastian Fifanski, thesis title: *Flexure-based mecano-optical multi-degree-of-freedom transducers dedicated to medical force sensing instruments*.
Completed June 2020.

Etienne Thalmann, thesis title: *Flexure Pivot Oscillators for Mechanical Watches*.
Completed June 2020.

Michal Smreczak in collaboration with Imina Technologies SA, preliminary thesis title: *Load cell with tunable stiffness dedicated to force measurement at the nano-Newton range*.
Expected completion September 2021.





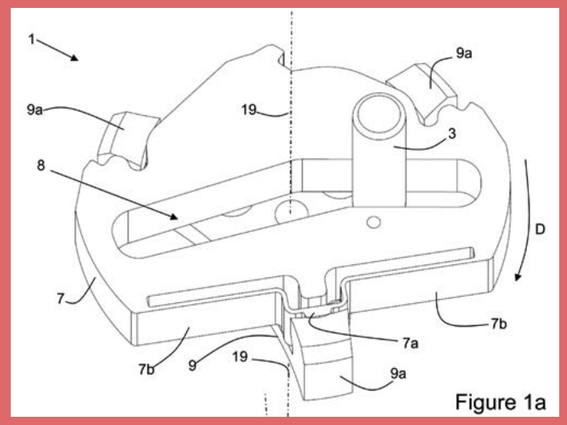
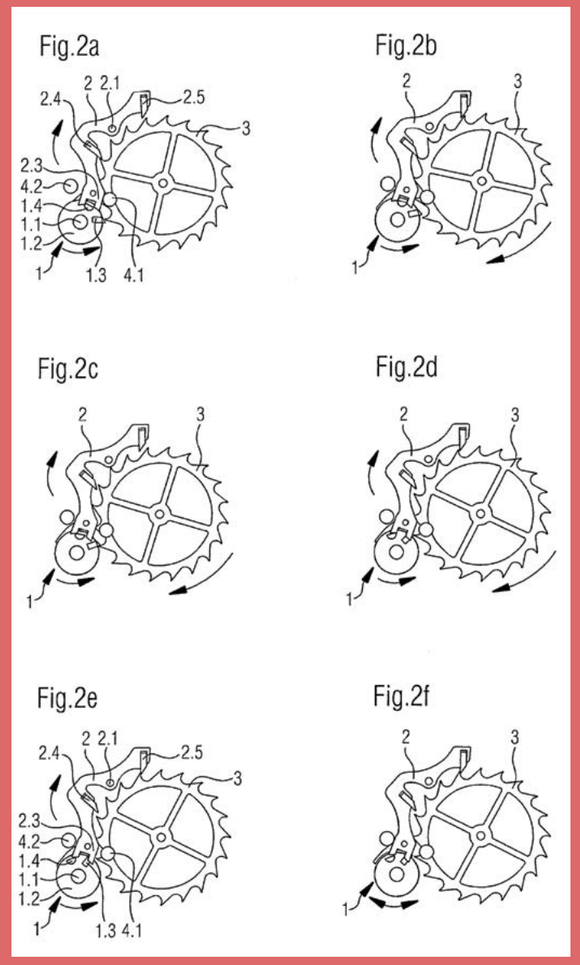


Figure 1a



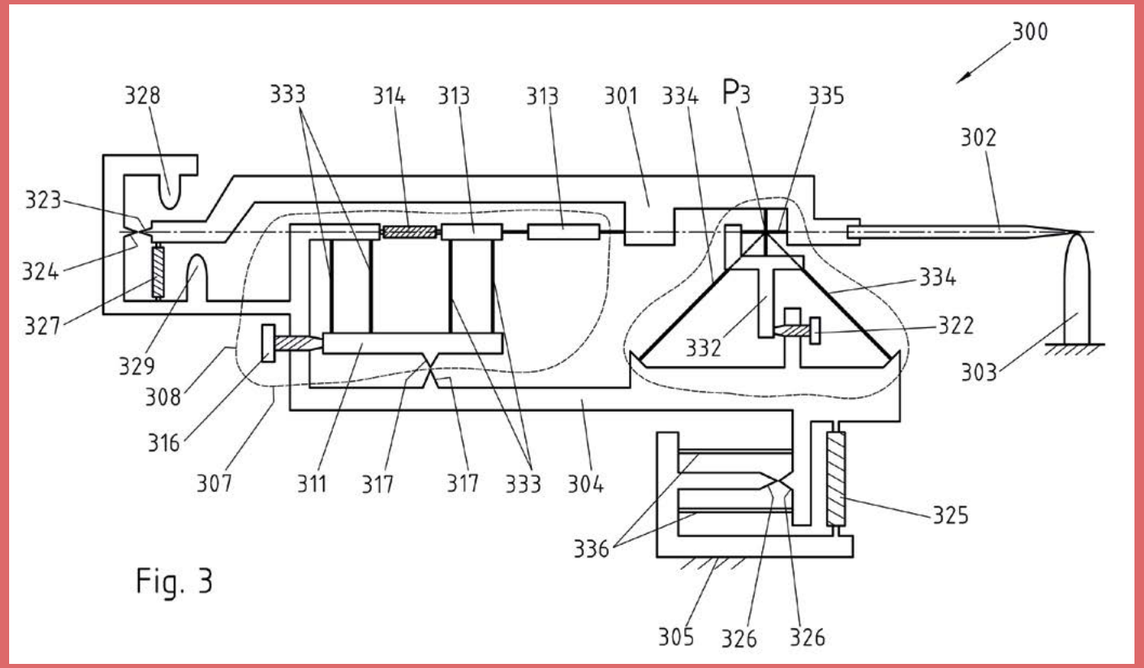


Fig. 3

PUBLICATIONS

Patents

M. H. Kahrobaiyan, E. Thalmann, S. Henein, *Flexure Pivot Oscillator Insensitive to Gravity*, WO2020016131(A1), Assignee : Patek Philippe SA, 2020.

S. Henein, I. Vardi, L. Rubbert, *General two degree of freedom isotropic harmonic oscillator and associated time base without escapement or with simplified escapement*, US2019227493A1, Assignee : EPFL, 2019.

S. Henein, B. Nussbaumer, R. Gillet, *Crank arrangement for driving a mechanical oscillator*, EP 19174824.3, 2019.

S. Henein, Ch. Baur, Th. Fussinger, H. Schneegans, L. Bonnefoy, *Sensor System*, 19159811.9-1003, 2019.

M. H. Kahrobaiyan, Ch. Baur, S. Henein, M. Zanaty, *Device for measuring a force exerted on an object*, 19168414.1-1001, 2019.

S. Henein, M. H. Kahrobaiyan, I. Vardi, B. Nussbaumer, E. Thalmann, *Horological oscillator*, PCT / EP2019 / 051188 / WO2019141789A1, 2019.

I. Vardi, S. Henein, O. Mathez, *Automatically Starting and Secured Detent Escapement for a Timepiece*, US 2019 / 0361397 A1, November 28, 2019.

Journal articles

P. Flückiger, I. Vardi and S. Henein, *Foucault pendulum properties of spherical oscillators*, Review of Scientific Instruments 91 (2020), pp. 095115-1 to 095115-8.

M. Zanaty, P. Flückiger, I. Vardi, S. Henein, *Programmable Multistable Mechanisms for Locomotion*, Bulletin of the American Physical Society 65, 2020.

C. Forestier-Kasapi, I. Vardi, *L'horlogerie centrée client*, Bulletin de la Société Suisse de Chronométrie 89, p. 3, 2020.

M. Zanaty, H. Schneegans, I. Vardi, S. Henein, *Reconfigurable Logic Gates Based on Programable Multistable Mechanisms*, Journal of Mechanisms and Robotics of the ASME 12, pp. 021111 to 021124, 2020.

E. Thalmann, M. H. Kahrobaiyan, I. Vardi, S. Henein, *Flexure Pivot Oscillator with Intrinsically Tuned Isochronism*, Journal of Mechanical Design 142, pp. 075001 to 0755014, 2020.

M. Zanaty, Th. Fussinger, A. Rogg, A. Lovera, D. Lambelet, I. Vardi, Th.J. Wolfensberger, Ch. Baur, S. Henein, *Programmable Multistable Mechanisms for Safe Surgical Puncturing*, Journal of Medical Devices 13, pp. 021002-1 to 0211002-10, 2019.

M. Zanaty, H. Schneegans, I. Vardi, S. Henein, *Programmable Logic Gates Based on Turnable Multistable Mechanisms*, Proceedings of the ASME International Design Engineering Technical Conferences / Computers and Information in Engineering Conference, Anaheim, CA, 2019.

I. Vardi, S. Henein, *À la recherche du temps précis : la découverte de l'oscillateur*, Actes du Congrès International de Chronométrie 2019 de la SSC, Montreux, pp. 9 to 16, September 25th-26th, 2019.

S. Martin, *Mesearch and the performing body*, Dance Research 37, Edinburgh Univ. Press, pp. 120-121, 2019.

E. Thalmann, S. Henein, *Conceptual design of a rotational mechanical time base with varying inertia*, engrXiv, doi :10.31224/osf.io/kjhbx, submitted 2020.

Ph.D. Theses

S.K. Fifanski, *Flexure-based mecano-optical multi-degree-of-freedom transducers dedicated to medical force sensing instruments*, EPFL Ph.D. Thesis 9628, Lausanne, 2020.
E. Thalmann, *Flexure Pivot Oscillators for Mechanical Watches*, EPFL Ph.D. Thesis 8802, Lausanne, 2020.

LECTURES, INVITED TALKS, POSTERS

S. Henein, *Performing art improvisation techniques for mechanical engineering design teaching and learning*, IGM Colloquium, EPFL, Lausanne, December 1, 2020.

S. Martin, *Tanzende Universitäten ?*, Scenario Forum Online Research Colloquium, November 28, 2020.

S. Martin, *Tanzimprovisation für die Universität – Gewohnheiten in Bewegung*, Saalfrei Festival Stuttgart, October 26, 2020.

P. Flückiger, *Design of a Flexure Based Low Frequency Foucault Pendulum*, International Design Engineering Technical Conferences / Computers and Information in Engineering Conference, IDETC-CE Virtual Conference, August 19, 2020.

H. Schneegans, *Statically and dynamically balanced oscillator based on Watt's linkage*, 20th International conference of the European Society for Precision Engineering and Nanotechnology (Euspen)., Geneva, June 9, 2020.

P. Flückiger, *Foucault properties of spherical oscillators*, 20th International conference of the European Society for Precision Engineering and Nanotechnology (Euspen), Geneva, June 6, 2020.

S. Martin, *Improvising to Collaborate – Collaborating to Improvise*, Stockholm University of the Arts, Research Week 2020, January 21, 2020.

I. Vardi, *La qualité de la précision*, Conference "Réflexions autour de la précision horlogère", International Museum of Horology, La Chaux-de-Fonds, December 16, 2019.

I. Vardi, *À la recherche du temps précis : la découverte de l'oscillateur*, Congrès International de Chronométrie SSC, Montreux, September 25-26, 2019.

Ch. Baur and Prof. Th. J. Wolfensberger, chief physician at Jules-Gonin Hospital, presented the *Safe Puncture Optimized Tool for Retinal Vein Cannulation* at EPFL Research Day Neuchâtel, September 11, 2019.

Ch. Baur, *SPOT : a femto laser printed tool made out of fused silica for safe retinal vein cannulation*, EPFL Research Day Neuchâtel, September 11, 2019

S. Martin, *Bodies in the Making*, Symposium Soundance Festival, Berlin, June 22, 2019.

S. Martin, *Learning to Improvise – Improvising to Learn*, Ascopet Symposium, EPFL, June 13, 2019.

Ch. Baur, *SPOT : a femto laser-printed tool made of fused silica for safe retinal vein cannulation*, IS2M annual meetings, June 6-7, 2019.

S. Martin, *Improvising Bodies & Dance Making Minds : Initiating and Facilitating Improvisation Practice*, Im_flieger, Vienna, May 24, 2019.

S. Martin, S. Henein, *Improgineering – Performing arts improvisation to approach transversal competencies*, within the series "Lunch & LEARN" at Center for Learning Sciences (LEARN), EPFL, March 28, 2019.

S. Henein, S. Martin, *IMPROGINEERING or Move Towards the Unknown, Fall Into a Gap, and Find a Body There*, 10th SAR International Conference on Artistic Research, Zürich University of the Arts, Zürich, March 23, 2019.

S. Martin, *Improvisation and Engineering*, Eawag, The Swiss Federal Institute of Aquatic Science & Technology, Urban Water Management, January 25, 2019.

Patrick Flückiger receiving the Omega Scientific Award from the Head of the Institute of Microengineering for his Instant-Lab masters project

DISSEMINATION

S. Henein, IGM Colloquium, *Performing art improvisation techniques for mechanical engineering design teaching and learning*, EPFL, December 1, 2020.

I. Vardi, *Breaking the second barrier*, magazine Europa Star Premiere, September 2020.

S. Henein, J. Valterio, Release of the six final videos created by the Improgineering students, May 22, 2020.

S. Henein, J. Valterio, Release of the ASCOPET video presenting the pedagogical research initiated by Instant-Lab, April 24, 2020.

I. Vardi, *Réflexions autour de la précision horlogère* International Museum of Horology in La Chaux-de-Fonds, December 16, 2019.

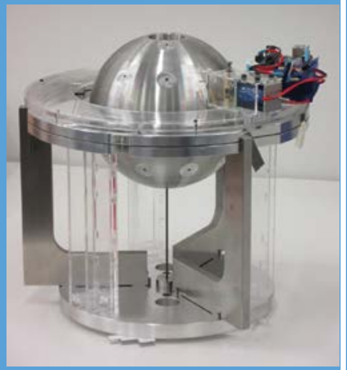
I. Vardi is part of the scientific committee who organizes the International Congress of Chronometry, Société Suisse de Chronométrie (SSC), Montreux, September 25-26. 2019.

P. Flückiger was awarded the Omega prize for his masters project *Spherical Isospring as a Pseudo-Foucault Pendulum*, September 2019.

Ch. Baur, Le projet SPOT à la RTS, *Cette minuscule aiguille est synonyme d'espoir pour 16 millions de patients*, August 2019.

S. Henein, L. Kloetzer, first conference on performance art in Higher education, *Symposium in Higher Education Learning through Performance Practices*, Lausanne, June 13-14, 2019.

FEMTOprint wins the “Grand Prix des Exposants” at the EPHJ fair in June 2019 with the SPOT project run in collaboration with Instant-Lab.



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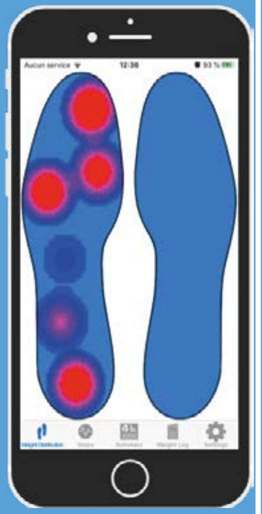





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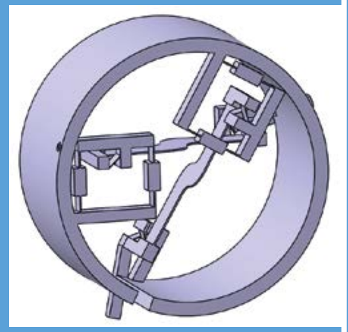

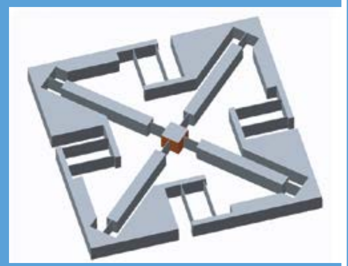

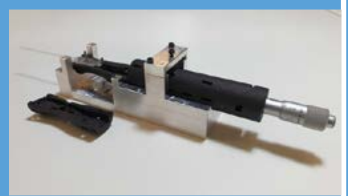
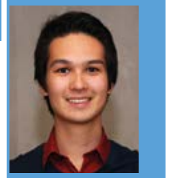
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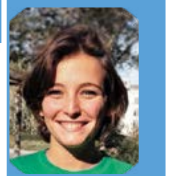
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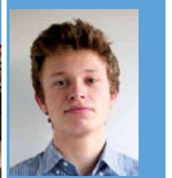
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TEACHING

The laboratory is strongly involved in teaching. Focus is on training creative design and learning the analytical tools necessary to model, simulate and predict mechanism behavior.

EPFL Courses

Mechanism design I & II (2019-2021)
Lecturer : Prof. Simon Henein ; Section : Microengineering (157 students) ; Bachelor semesters 3 and 4 ; three hours per week.

Collective creation : improvised arts and engineering I & II (2019-2020)
Lecturers : Prof. Simon Henein, Joëlle Valterio and guest lectures. 25 students ; Open to all sections ; Master semesters 1 and 2 ; three hours per week. Year-long course, EPFL Social and Human Sciences (SHS) program, developed in cooperation with the Centre d'art scénique contemporain (Arsenic), Lausanne.

Metrology (2019-2021)
Lecturers : Prof. Edoardo Charbon, D. Claudio Bruschini, Prof. Georg Fantner, Dr. Ilan Vardi ; Masters level course. Ilan Vardi is responsible for the metrology of time. EPFL.

EPFL Horological Competition (2021)
In August 2020, our laboratory established the EPFL Horological Competition, where EPFL students are challenged to satisfy specifications provided by the laboratory. This project is an EPFL Make interdisciplinary project. A call for students was made in September 2020 and the competition will begin in the Spring 2020 semester. The project will count as a student semester project.

Semester [S] and master [M] projects

2019

a. Spherical Isospring as a Pseudo-Foucault Pendulum, Patrick Flückiger [M]
b. Rocker Oscillator Clock, Vladimir Bourquin [S]
c. L'Enjeu des Tourbillons dans le Fonctionnement d'une Montre Mécanique, Anthony Dotta [S]
d. L'Enjeu des Tourbillons dans le Fonctionnement d'une Montre Mécanique, Andrea Elisei [S]
e. Rehabilitation insole for progressive weight application, Florian Josselin [S]
f. Tennis ball with sound system for visually impaired people, Christophe Muller [M]

2020

g. Cell cultures state of the art review and organoid scaffold flexure design optimization, Laura Wagnières [S]
h. Haptic weather vane for visually impaired people, Victor Tiberghien [S]
i. Micro Watch, Saravath Lor [S]
j. Conception d'un dispositif médical mécanique permettant d'ouvrir et de fermer un sphincter vésical, Sven Borden [S]
k. Rehabilitation insole for progressive weight application, Valentin Lapeyre [S]

Internships

2019

l. Dimensioning and simulation of a flexure pivot oscillator, Julia Bierent
m. Fabrication of flexure pivot oscillator mock-ups, Simon Prêcheur Llarena
n. Redesign of SPOT-RVC actuation handle and conception of its mounting base, Laura Wagnières

PEDAGOGICAL ACTIVITIES

Practice

Professor Henein held the third edition of his course linking the engineering and humanities faculties of the EPFL : “ Collective creation : improvised arts and engineering ”. This year-long course, which was launched in September 2017, is part of EPFL’s Social and Human Sciences (SHS) program and was developed in cooperation with the Arsenic theater (Centre d’art scénique contemporain) in Lausanne. The course examines the creative process in engineering design and improvisation in the performing arts. Experts in a wide range of disciplines ranging from theater to mathematics present students how creativity is expressed in their field of expertise. Workshops explore improvisation through the theater, music, dance and performance arts. The 25 students taking the class staged their final project in May 2019 in a dress rehearsal followed a week later by a final presentation before a board of examiners. Both events were open to the public. The edition of the course ending in 2020 lead to the publication of six collective videos created remotely by the students during confinement in replacement of the planned on stage performance. The videos are accessible on Instant-Lab’s web-page.

In August 2020, Instant-Lab launched the EPFL Horological Competition in which groups of students are challenged to design and build a clock satisfying specifications given by the laboratory. The goal of this initiative is to finally provide EPFL students an introduction to the watch industry, one of the cornerstones of the Swiss economy.

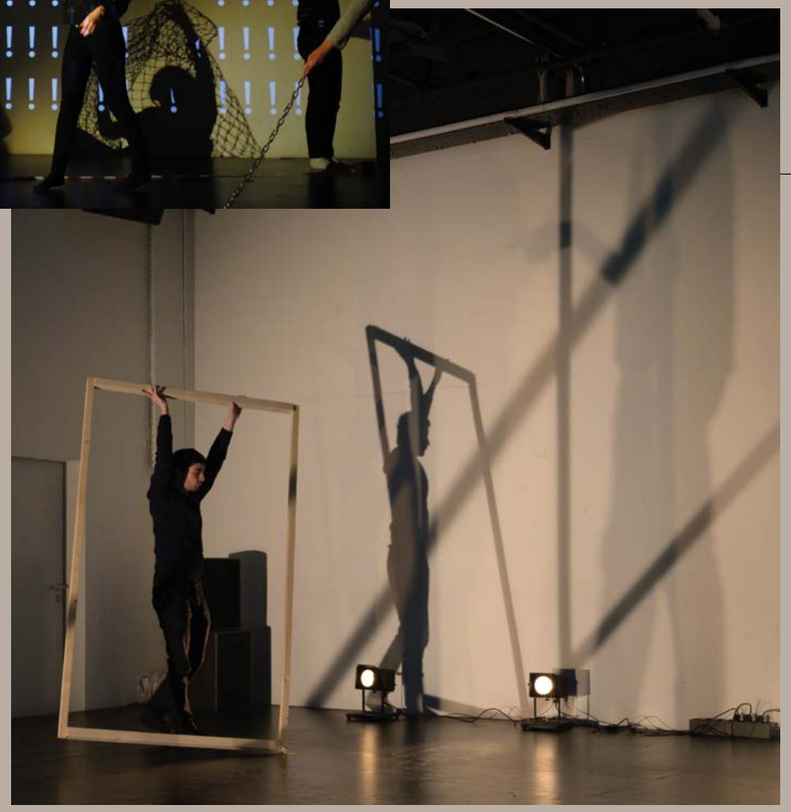
Research

In September 2018, Instant-Lab launched a research project in collaboration with Professor Laure Kloetzer of the Institute of Psychology and Education at the University of Neuchâtel.

The goal of this project entitled “ Performing Arts as Pedagogical Tool in Higher Education ” (ASCOPET) is to describe, analyze and evaluate the utilization of the performing arts in higher education.

The descriptive part of the project consists of data collection : video recordings, interviews and student essays. The analysis will identify specific pedagogical approaches inherent in the respective teaching methodologies and compare them. Evaluation will be achieved by appraising the relative benefits of these pedagogical approaches and their relation to the state-of-the-art.

This project is the basis of publications on the subject authored by Professors Henein and Kloetzer and postdoctoral fellows Ramiro Tau and Susanne Martin as well as a doctoral thesis by Martin Vergara.



Improgineering Workshop at the Arsenic Theatre, Lausanne.

Final public performance staged in May 2019 at Arsenic Theatre.

Jury of experts and public discuss with students after their performance.

Illustration used to describe the Reflexive Diaries to be written by the students.

CONCLUSION AND PERSPECTIVE

In 2014, Prof. Simon Henein announced the IsoSpring project to make the first mechanical watch without escapement. This led to patents and a large-scale industrial project which was successfully completed in 2017. This project was extended to a second phase focused on miniaturizing IsoSpring to the watch scale using the novel Wattwins concept.

Our laboratory continues its mission to the dissemination and transmission of horological culture. Dr Ilan Vardi, senior scientist of our laboratory, was nominated to the Scientific Committee of the Société Suisse de Chronométrie. In this role, he provided the theme of *Research, Past, Present, Future* of the 2019 International Congress of Chronometry. We also launched the EPFL Horological Competition which finally introduces EPFL students to mechanical watchmaking.
Our medical research continued with the publication of our design and experimental results of a millimeter scale medical device featuring multistable flexure mechanisms realized in fused silica (glass). These features allow for safe puncturing of very delicate veins inside the human eye for the treatment of retinal vein occlusion.

These years mark the second and third edition of the new course bridging engineering and humanities. A new collaboration with the University of Neuchâtel and the University of Lausanne studies the pedagogical processes associated to this novel teaching approach.

After the successful completion of the first phase of the IsoSpring project, the goal of the second phase is to have a functional watch demonstrator with an IsoSpring time base.

We are continuing our fundamental research, for example, by proposing new Foucault pendulum oscillators with novel and unexpected properties, leading to publications and the Omega Prize for Patrick Flückiger's master's thesis.

Our teaching activities expanded with the participation in a new metrology course and the creation of a new course covering structural mechanics and mechanism design, as well as continuing our teaching in the Social and Human Sciences program.

M. Zanaty receiving his Ph.D. diploma from his thesis directors. Dr Zanaty has been awarded an Early Postdoc Mobility Fellowship form the Swiss National Science Foundation at the Harvard School of Engineering and Applied Sciences, Cambridge, USA. Etienne Thalmann and Sebastian Fifanski also successfully defended their theses and were awarded Ph.D.'s in June 2020.

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