# Online Experimentation: Emerging Technologies and IoT

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# Foreword

If you "dream things that never were and say, why not?"[1] Then this book will inspire you. The chapters sometimes provide a peek into possible futures and sometimes provide a flood of ideas that leave one reeling. One research area of intense interest to me is that of online experiments, with a particular interest in remote laboratories applied to physics and electrical engineering. Traditionally there are two types of online experiments considered by researchers: remote laboratories (based upon remote access to physical equipment) and virtual laboratories (based upon access to simulations and virtual reality). These two variations of online experiments are nearly always treated as separate research areas. Additionally, remote laboratories that require replenishment of a resource are almost never attempted, as they do not scale to handle large numbers of users. In one chapter of this book the reader discovers a project that integrates these two types of laboratories. That chapter describes an experiment based on an FPGA implementation of a controller for a simulated water tank, so the water never runs out nor needs cleaning. This combination of physical hardware and simulation/virtual reality/augmented reality should open a novel approach to new online experiments. In many of the chapters the reader is presented with other similar beautiful insights.

This book provides glimpses into contemporary research in the domain of remote experiments, but the ideas also range over the domains of telehealth, collaborative learning environments, the role and use of mobile devices, brain-computer interfaces, haptic feedback (with one application in training dentists), virtual reality and materials processing.

Great research arises from asking great research questions. Warren Berger discusses this topic in his recent book A More Beautiful Question. He defines a beautiful question as one that is "an ambitious yet actionable question that can begin to shift the way we perceive or think about something - and that might serve as a catalyst to bring about change". As one reads the chapters of this book one begins to see some of the "beautiful questions" that the authors develop and how the subsequent "what if" and "how" questions are developed.

After reading this book (or those chapters that take your interest) take some time to think of your "beautiful question". We look forward to reading about your work in the books that will follow from Teresa Restivo, Alberto Cardoso and António Lopes, the editors of this book.

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[1] Paraphrased from Robert Kennedy who said "Some people see things as they are and say why? I dream things that never were and say, why not?" In fact Kennedy paraphrased George Bernard Shaw who originally said in his play Back to Methuselah "You see things; and you say 'Why?' But I dream things that never were; and I say 'Why not?'" Check the full story on http://www.quotecounterquote.com/2011/07/i-dream-things-that-never-were-and-say.html.

# Preface

The Experiment@International Conference series (exp.at’xx) is a biannual event dedicated to online experimentation, contributing to extend the world capabilities in this particular area and to develop collaborative work in emerging technologies, bringing together engineers, researchers and professionals from different areas in a really interdisciplinary approach, with interest for higher education, at research level and for industry. It also has a strong expression in the medical area, where the collaboration of engineers and engineering scientists is in rising demand.

exp.at'xx aims to contribute to expand the concept and follow the evolution of Online Experimentation (OE) which comprises remote and virtual experimentation as identifiable and accessible objects and their virtual representations in the Internet of Things (IoT) structure. OE is aided by emerging technologies, such as those supporting remote experiments, 2D or 3D virtual experiments, augmented reality experiments and their interaction with sensorial devices, live videos and other tools, such as interactive videos and serious games, additionally helping to support user immersion in virtual environments recreating the real experience [1, 2].

The evocative name, Experiment@, is adequate to turn the event into an itinerant forum to foster the expansion and association of online experimentation [2], stimulating interdisciplinary discussion and collaboration by bridging the gap between academic applications and results, as well as real world needs and experiences.

Additionally, OE offers new tools for improving knowledge in a society facing a faster technology growth than ever before and clearly involved in a society completely influenced and dominated by the information age as it is the IoT era.

In the closing ceremony of the exp.at’13 conference an invitation was made - to edit a book with contributions from the participants and associated authors. The writing, the submission process and the two steps of reviewing work have joined us all during the past two years in a real OE network for sharing perspectives and ideas. The present work is the final result of such a challenge.

The title of this book, "Online Experimentation: Emerging Technologies and IoT", tells the readers that it is based on online experimentation, using fundamentally emergent technologies to build the resources and considering the context of IoT.

The IoT is a "global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies" [3].

A “Thing” in IoT can be any object that has a unique identifier and which can send/receive data (including user data) over a network as the existing Internet infrastructure [4].

In this context, each OE resource can be viewed as a “thing" in IoT, uniquely identifiable through its embedded computing system, and considered as an object to be sensed and controlled or remotely operated across the existing network infrastructure, allowing a more effective integration between the experiments and computer-based systems.

The various examples of OE can involve experiments of different type (remote, virtual or hybrid) but all are IoT devices connected to the Internet, sending information about the experiments (e.g. information sensed by connected sensors or cameras) over a network, to other devices or servers, or allowing remote actuation upon physical instruments or their virtual representations.

The contributions of this book show the effectiveness of the use of emergent technologies to develop and build a wide range of experiments and to make them available online, integrating the universe of the IoT, spreading its application in different academic and training contexts, offering an opportunity to break barriers and overcome differences in development all over the world.

This Book comprises a total of 26 chapters, which are outlined below.

**Chapter 1**, by V. Santos and P. Quaresma, presents the Web Geometry Laboratory (WGL) as a collaborative blended-learning web-environment for geometry. The WGL can be used in a classroom or remotely. When planning a collaborative work session, the teacher has to decide how to group the students and design the tasks to be solved collaboratively, i.e., to prepare a set of geometric constructions, as starting points for tasks to be completed during the class, and/or illustrative cases, and/or other activities.

**In Chapter 2**, T. Rocha et al. propose a framework for telehealth stream analysis, based on pattern recognition techniques that evaluate the similarity between multivariate biosignals. The strategy combines the Haar wavelet with the Karhunen-Loève transform to describe biosignals by means of a reduced set of parameters. The approach is based on the hypothesis that the future evolution of a given biosignal (template) can be estimated from similar patterns existing in a historical dataset.

**In Chapter 3**, M. J. G. Figueiredo et al. present a survey of the most popular augmented reality applications. The main goal is to select augmented reality (AR) eco-systems, for educational purposes, that are user friendly, do not require programming skills and are freely available, so that they can be used in class. The authors also present teaching activities created with those tools that use different AR technologies for creating animations, 3D models and other items to be displayed on top of interactive documents. The examples presented are used in kindergarten educational activities and in elementary and secondary schools to improve the learning of music and orthographic views.

**In Chapter 4**, M. Serrhini addresses the design of an interactive web lab, where students' attention is controlled during experimentation by an assessment system based on EEG brain computer interface (BCI) technology. The final goal is to measure and check the concentration of student attention by BCI through alpha and beta wave frequency measurements. The proposed system plays a role as an intelligent tutoring system (ITS) that will alert the student about his/her inattentiveness during experimentation.

**Chapter 5**, by S. L. Gordon and J. Wolfer, presents a set of courses for contextual instruction and profiles the deployment of a haptic infrastructure to help support that instruction, as well as projects that use that haptic infrastructure. Two contextual motifs are described to support a variety of classes: a robot context for teaching assembly language programming, and a biomedical context for artificial intelligence, computer graphics, and computer literacy classes.

**In Chapter 6**, A. Z. Sampaio and A. M. Gomes develop a technological tool for supporting building maintenance, with resort to new information and visualization technologies. Three main components of the building are analyzed: roof, facades and interior walls. The basic knowledge related to the materials, the rehabilitation and conservation techniques and the planning of maintenance are outlined and discussed. In addition, methods for interconnecting that knowledge with virtual applications are explored.

**In Chapter 7**, S. C. Leal and J. P. Leal present two chemistry experiments included in the "e-lab" remote laboratory, at Instituto Superior Técnico, Lisbon, that allow students of primary and secondary schools to consolidate their knowledge in science and hence develop their scientific skills.

**Chapter 8**, by R. Cordeiro et al., discusses the issues of combining intelligent tutoring systems and collaborative environments with online labs. The scenario envisaged replicates that of hands-on laboratories where students typically work in groups (i.e. they collaborate with each other in order to complete an experiment) and are supported by a tutor who is physically present during the lab session. Providing these conditions in situations where students perform the experiments in a (virtual, remote, or hybrid) online lab is the key aspect discussed.

**In Chapter 9**, L. Rodriguez-Gil et al. describe the integration of an educational electronic design tool in a remote laboratory, and the implementation and addition of a hybrid (virtual and remote) laboratory. The goal is to provide an extended educational process that helps improve the teaching and learning of digital electronics. The tools and the workflow adopted allow students to easily design and implement their own digital system.

**In Chapter 10**, C. Barros et al. present an innovative remote laboratory for physiological data acquisition, directed to biomedical engineering students. The laboratory development was based on biotelemetry with pedagogical purposes. Its main goals include signals recognition, remote control and configuration of the physical devices and observation of cause-effect relationship with parameter changes.

**Chapter 11**, by C. Onime et al., introduces mobile augmented reality (semi-immersive 3D virtual reality) as a vehicle for the delivery of practical laboratory experiments in science, technology and engineering. Mobile augmented reality provides multi-sensorial interactions with a computing platform over commodity hardware technology that is already widely accepted. Two examples in the fields of micro-electronics and communications engineering highlight the innovative features, such as the ability to closely replicate an existing laboratory based hands-on experiment and the use of the mobile augmented reality experiment as a blended learning aid for laboratory experiments or stand-alone off-line experiments for distance learning.

**Chapter 12**, by M. Huba et al., introduces the performance portrait method (PPM) for controller tuning. The PPM is illustrated by means of an online application that enables users to interact in several steps of the controller design. The PPM is developed on open software environments such as Octave and OpenModelica installed on a server.

**In Chapter 13**, E. Ossiannilsson proposes a frame of reference for mobile learning. The main focus is on the quality issues in open educational arenas and in designs for mobile learning and personalization, which ought to be seen from a holistic point of view. In particular, the author claims that quality dimensions from the learner's perspective have to be taken into account with regard to quality enhancement and quality assurance for mobile learning.

**In Chapter 14**, L. B. Michels et al. discuss the development of a remote experiment that uses a remotely controlled didactic press to illustrate a fundamental topic of mechanical engineering: Hooke's Law. The purpose of the experiment is to experimentally demonstrate the theory by applying force on a helical car suspension spring. The communication, processing, acquisition and control of data are made through a Raspberry Pi microcomputer, resulting in one of the first applications of this technology in a remote laboratory in the area of Materials Engineering.

**Chapter 15**, by A. Zimin et al., presents the Bauman Moscow State Technical University (BMSTU) Remote Access Laboratories. These laboratories are designed for shared use by universities in Russia and other countries. The computer-based Dispatch & Information System created in BMSTU enables remote users to apply for and carry out experiments via personal cabinets, to store and process the data obtained, while the system administrator controls the operation of laboratory equipment. The Internet laboratories at BMSTU involve a wide range of multimedia technologies which make it possible to observe the experiments and establish audio-visual contact with the equipment maintenance personnel.

**Chapter 16**, by A. Maiti et al., discusses the benefits and challenges of a distributed remote access laboratory (RAL), as well as the technical means to implement it. The distributed RAL system aims to bring both the experiment building and running closer to the users. The entire system is to be run by the users or 'maker' community. Once the maker has created and tested the equipment successfully, the experiments are online for others to access and the instruments at the experiments side may be operated via the Internet by the users.

**In Chapter 17**, R. Krneta et al. present a blended learning environment, integrating online and hands-on laboratory practices together with learning of theoretical concepts, within an engineering course in digital signal processing (DSP). A student survey is carried out concerning Kolb's inventory of learning styles and preferred type of lab exercises. Survey results are discussed from the perspective of matching different learning styles with preferred type of DSP exercises.

**In Chapter 18**, S. C. Leal et al. focus on remote labs that can bring together both experimental and technological parts. They address the "e-lab" project at Instituto Superior Técnico, Lisbon. This remote laboratory is a continuous process that aims to improve the tools that already exist and create new support materials for teachers and students. The platform is currently directed to Portuguese speakers only (essentially from Portugal and Brazil) but there is already a concern to have all the information in English, so that it can be used worldwide.

**In Chapter 19**, R. J. Costa et al. propose the use of the IEEE1451.0 Standard (Std.) to fulfill software and hardware requirements for designing and accessing weblabs. By describing the weblab modules according to the IEEE1451.0 Std. and using standard HDL (Hardware Description Language) files, those modules can be easily replicated and shared through different weblab infrastructures, which promotes the design of reconfigurable and standard-based weblabs using embedded smart modules.

**Chapter 20**, by C. Onime et al., presents with real/practical examples and illustrations from a multi-disciplinary course for physics/engineering, the quasi-automated exportation of an on-line learning content management system (LCMS) and massive open on-line courses (MOOCs) into an off-line portable archive that is especially suited for use in areas/regions with limited bandwidth. Also discussed/presented is the use of the off-line version in several contexts such as personal learning, interactive classroom video, collaborative learning, distance learning and even as a blended learning aid for existing classroom based academic programs or on-line MOOCs or LCMS based courses.

**Chapter 21**, by R. Sell et al., presents an innovative framework concept combined with online labs for the teaching and learning of engineering subjects. The concept integrates comprehensive approaches of different classical and innovative descriptions. Practical results and feedback of learners after application of the concept in practice are described.

**In Chapter 22**, J. B. da Silva et al. present an initiative to provide remote access to experiments through mobile devices. Techniques based on information and communication technologies (ICT) were adapted and applied to educational environments, according to the available infrastructure and the common characteristics of basic education schools. This study also integrated many features of the virtual learning environment (VLE) for providing educational material, access to remote experiments and use in mobile devices. The methodology applied in the practical activities was based on TPACK (technological pedagogical content knowledge), a model that allows understanding and describing the types of knowledge that teachers need for efficient integration and planning of learning activities using ICT.

**In Chapter 23**, X. Ping-Jun et al. review the application of virtual reality and haptics in different areas, namely in the industrial environment for product assembly, in the medical setting for surgical simulation, and in the educational area for remote experiments. Some new ideas and typical systems are investigated, the major research efforts are discussed, and recent research progress from the authors' research group is introduced. Then, barriers and future trends are discussed.

**In Chapter 24**, T. da Silva and M. Loja present an educational simulation platform aimed to help mechanical and structural engineering students to explore the combination of thermal and hygroscopic residual stresses that arise when a manufacturing process involves a high temperature or moisture content environment, and a subsequent transition to ambient environment conditions. This fact is particularly important when structures are made of composite materials. The authors present and discuss a set of illustrative cases of hygrothermal residual stress analysis and optimal design considering their minimization.

**In Chapter 25**, by S. Paredes et al., a software application is presented to reduce the potential unavailability of risk scores to assess the risk of a patient in daily clinical practice. Based on the developed tool, the physician can easily assess the risk of a specific patient along with the configuration of the global model adjustment.

**Chapter 26,** by M. Ožvoldová and F. Schauer, presents four remote experiments in the area of Mechanics aimed to explain real world phenomena. The remote experiments are built using the Internet School Experimental System (ISES) physical hardware. Their transformation to remote experiments is carried out by the Easy Remote ISES programming environment, creating control programs in JavaScript for remote experiments and controlling web pages without programming, by the expert questionnaire approach.

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