Utilizing Open Spaces for community-driven Development of XR Teaching Applications in Photonics

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Abstract: We present an approach of developing XR teaching applications by implementing open spaces as a hub for the photonics community and developers interested in XR technologies and give a first evaluation of technologies and platforms.

1. Introduction

From Fourier waves to nanostructures and up to quantum mechanics - modern photonics is sometimes hard to grasp and lays way beyond human everyday experience. Extended Reality (XR) applications are a promising way for visualizing, communicating and teaching findings and scientific facts in this field. By virtualization and augmentation, information can get haptically experienced in a 3D-space and augmented on to existing setups or into educational environments. Unfortunately, the software development of such applications requires skills and resources, which usually can not be easily provided by members of the scientific photonics community. Otherwise, our experience showed that there is a large number of interested people who would like to get involved with XR technologies. So in contrast to commission the development to a company, we like to present an approach we took by implementing the makerspace "Lichtwerkstatt" as a hub for open community-driven project development. In this paper, we discuss the steps we took to reach potential developers, how we connected them with the science community and which technology decisions we made to foster a fair and equitable development environment.

2. The Open Photonics Makerspace Lichtwerkstatt

The Lichtwerkstatt is an open makerspace with a focus on photonics established in 2017 and funded by the German Federal Ministry of Education and Research. It enables and supports open innovation processes [2] in the photonics industry for established companies and start-ups by integrating the maker-community into innovation processes. Key elements are the organization of events to fasciliate knowledge transfer and the provision of prototyping tools for photonics professionals and the interested public [1]. By doing so, the Lichtwerkstatt is today a well-known local partner for technology and maker-topics with an extensive network of creative minds, researchers and tinkerers.

A crucial aspect of our work in XR technologies is our strong partnership with institutions like the Max Planck School of Photonics (MPSP). Due to several initiatives like the Digital Teaching Lab (DTL) towards digitalization of education and teaching, we have access to a wide range of XR-specific technologies. Further, these partners also act as valuable application providers and reviewers of our ongoing XR projects.

3. Approach towards community-driven Development

To get developers interested in XR and connected to the photonics science community, we followed a two-sided approach. First, we collected ideas and applications valuable for integration into an XR environment. We hereby did not solely concentrate on photonics education and training programs, but pursued a broader approach involving science communication, technical aspects of lab work as well as XR technologies themselves. We also collected requirements and already existing assets, such as 3D CAD-models.R egarding to the concept of makeathons, we

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also tried to establish a mentor program to enable a bilateral discussion between scientists and developers.
Second, we established various event formats and channels around XR-related topics to build a net-work of developers interested in XR. The Lichtwerkstatt operates as a central hub providing the communication (e.g. Slack or Discord), organization (e.g. Confluence or Wikis) and infrastructure (e.g. GitHub Instance).

Workshops are a reliable format to train technological skills. We especially organized several ones about the open source graphic suite Blender to provide scientists with the ability to generate 3D scenes and assets, which is useful for potential integration in an XR environment.

Makeathons offer the possibility to try out new technologies for participants. We formulated projects with industry and science partners, which include links to development tasks in the game engine Unity or gamification aspects.

Lectures: During the summer semester of 2021, the Lichtwerkstatt organizes a lecture about innovation methods in photonics. In the practical part, students work in teams on hard- and software projects from industry and science partners. Some of these projects involve the integration of XR technologies.

Students can work at the Lichtwerkstatt on their master's or bachelor's thesis. We communicate the possibilities and advantages of XR-related projects. We also supervise high school students, where topics around gaming engines and technologies are a preferred topic for practical seminars and training.

Research Assistants work on loose ends of unfinished projects, test new technologies and methods as well as follow their own ideas. These students can get involved in the other formats and gain deep technological skills over the time.

4. XR Projects and Technical Evaluation

The developed projects hereby cover various aspects of photonics. Some are oriented towards existing experimental setups like for example an Augmentation of a photoemission electron microscope (PEEM) or a VR model of a single qubit gate simulator, which are intended to enable informal learning in classrooms or at home. Others are extensions to existing projects like the modular optics toolbox UC2 [3]. In this project, a student group is developing an AR version of the accompanying workshop material for self-reliant learning with a mobile device. Another project XRTLab targets technical aspects of lab work by offering a VR and AR endpoint for automated and connected lab components. Besides building useful applications, which enhance future learning and education, we especially want to test a broad spectrum of technologies regarding defined criteria to narrow down future development processes. Unfortunately, some of these criteria appear to be quite opposed. Third-party platforms like Adobe Aero or Artivive allow the designing of AR scenes in a way, which is feasible for non-developers, like for example scientists. But compared to the tested professional environments like Unity or Unreal Engine, the possibilities in design and publishing of the app are quite limited and costly. Working with these game engines on the other side demands extensive training or an existing skill set. Another criterion is the licensing of software tools. A fair community-driven development is only possible with a result under open source license and widespread available tools. Where state-of-the-art development environments (like e.g. Unity or Unreal Engine) are at least free of charge for such projects, we experienced major differences regarding the software packages for XR support. While there are open solutions for image or object tracking like AR Foundation, commercial plugins like the Vuforia library or MARS work much better. The last criterion is the availability of devices and access to publishing platforms. It can be assumed that everyone has a mobile device, whereas Microsoft Hololens or VR Googles are much less common. To overcome this potential gap when learning in large learning groups, one of our student groups is developing an experimental approach of distributing XR content between different environments using the open source web framework AFrame and distributed database GunDB. Regarding the next steps, we like to evaluate the developed applications in learning environments and try to integrate the generated feedback step with workshops as an integral part of the existing development community.

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