Kongsberg Vision Meeting 2019: Abstracts

Kongsberg Vision Meeting was held at the University of South-Eastern Norway in Kongsberg, for the twelfth time, on November 5–7, 2019. The meeting was organised as a three-day meeting with a clinical day, research day and a lighting design day.

Rigmor C. Baraas, Ellen Svarverud, Trine Langaas and Are Røysamb organised the three-day meeting. The theme this year was Immersive technologies for eye care and lighting design. Keynote speakers for the clinical optometry day and the research day were Dennis Levi and Andrew Glennerster. The keynote speakers for the light day was Kynthia Chamilothori. The abstracts from invited and contributed talks on the different days are presented in the order they were given.

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Immersive optometry

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Abstract

Immersive technology blurs the boundary between the physical and the virtual world, and creates a sense of immersion. The technology has a continuum from reality to virtuality providing degrees of mixed realities where physical and virtual objects co-exist. At one end, augmented reality (AR) merges the real and virtual world. At the other end, virtual reality (VR) allows actions in a simulated real world. The use of immersive technology can be defined by the Stimuli-Organism-Response (S-O-R) framework. The framework proposes that system features, such as sensory and perceptual stimuli and content topics (S), influence cognitive and affective reactions of the user (O) which affect the outcome of immersive technology use (R) (Suh & Prophet, 2018). Research has demonstrated both positive and negative outcomes of immersive technology use. Positive outcomes relate to learning effectiveness, engagement and attitude, reduction in disease symptoms, as well as intention to continue. Negative outcomes are motion sickness, cognitive overload, physical discomfort, and distraction of attention.

Immersive technology has potential implications for optometry in terms of patient care, clinical practice, and professional training. However, research on the use of immersive technology in optometry is limited. In optometry, immersive technology has many areas of application, including patient education and shared decision-making, examination of visual function and ocular health, vision rehabilitation, clinical communication, and professional training. Immersive technology provides an opportunity to immerse in virtual scenarios that are hard to envision, and allows the user to perceive, feel and cognitively process otherwise unavailable information (Suh & Prophet, 2018). The use of immersive technology may provide patients with understanding of the eye, vision, and ocular disease more effectively, and better engage them in decision-making, such as the choice of ophthalmic lenses. In the same way, the use of immersive technology may enhance learning of theoretical knowledge, clinical skills, and general competency in optometry students and optometrists. Evidence suggests that the use of virtual reality improves knowledge and skills more than traditional and other types of digital education, and that higher interactivity is more effective than low interactivity (Kyaw et al., 2019). Further, the use of immersive technology may enhance the vision and eye examination, broaden optometrists' diagnostic toolbox, and strengthen collaboration with other healthcare providers in terms of assessment, clinical reasoning, and clinical decision making, by means of access to examinations, novel examination procedures, visualization of test results, and telecommunication. Based on the S-O-R framework, the use of immersive technologies may also enhance engagement and adherence to treatment. Studies show potential for the use of immersive technology in treatment of amblyopia, binocular vision problems, and vision rehabilitation.

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Recovering stereovision

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Abstract

Stereopsis is the impression of three-dimensionality—of objects "popping out in depth"—that most humans get when they view real-world objects with both eyes, based on **binocular disparity**—the differences between the two retinal images of the same world. However, a substantial proportion of the population is stereoblind or stereo deficient due to strabismus and/or amblyopia. This impairment may have a substantial impact on visuomotor tasks, difficulties in playing sports in children and locomoting safely in older adults. Impaired stereopsis may also limit career options. This talk will review several promising new approaches to improving stereovision in normal healthy observers, and recovering stereopsis in those with impairments, through perceptual learning and videogame play.

Improving health and education with immersive technologies: a case study from the Built in Bradford project

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Abstract

How can recent advances in immersive technologies improve life outcomes for the next generation of children? The *Born in Bradford* (BiB) project is one of the most important longitudinal birth cohort studies in the world. We have linked health, education and social care data from the Region's children since 2007. These data help us understand the interacting factors that enable children to reach their potential and lead healthy, happy lives. *Built in Bradford* will extend this research by recruiting all children starting secondary school with the BiB children (n = 24,000). Immersive technologies are at the heart of *Built in Bradford*, pushing the envelope on what science can do, and how it happens.

The scalability of virtual reality (VR) enables us to take the laboratory into schools (and museums etc). For the first time, we can undertake 3D kinematic assessments across an entire population. Our UXF platform (a Unity game engine plug-in) simplifies running behavioral experiments in VR. For example, we rapidly assessed > 400 participants in a VR baseball simulation, plotting the developmental trajectory of hitting from 5 years to adulthood, with performance on such tasks predicting mathematics attainment. Thus, school based VR assessments have the potential to identify children who are at risk of experiencing barriers to educational attainment.

The appeal of VR encourages teenagers to engage with science, deconstructing barriers to understanding, and enabling research coproduction. We have captivated and educated teenagers about science through the use of interactive VR demonstrations in schools. Furthermore, we hope to facilitate content learning in biology and physics by grounding abstract scientific concepts in interactive environments. Finally, with VR installed across the Region's schools, we hope that teenagers' enthusiasm for the technology can transform our science into a collaborative, city-wide enterprise. I will discuss how Bradford is becoming a trailblazing site for generating world class science through the use of immersive technologies – making healthier, happier lives a reality for future generations.

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VR or not to VR: Who will be excluded?

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Abstract
Immersive technology offers great possibilities to explore and develop effective learning, and an increasing interest in using the technology in schools as well as for entertainment is seen. Learning benefits may be particularly valuable in children and youngsters that find traditional teaching environments tedious or uninteresting.

Equipment for the display of virtual reality (VR) and augmented reality (AR) environments vary, but the artificial presentation produces a distorted version of space, which in stereoscopic (3D) displays also put different cues to depth in conflict with each other. The decoupling of accommodation and vergence systems required by 3D displays may cause symptoms of discomfort and visual fatigue, and persons with binocular vision problems or uncorrected refractive errors may even be unable to use the technology. Binocular vision may be challenged by input to the two eyes that differ from natural conditions. It is likely that underlying and/or untreated visual problems hamper the uncomplicated use of this equipment. In a closed Immersive VR system, the sensory inputs from vision may also be decoupled from the vestibular and proprioceptive systems, which naturally work together.

The documentation on possible adverse effects on vision and visual development after use of immersive technology are sparse and it is not yet clear which advice to give. This may be of particular worry since children who struggle at school may have a higher incidence of various visual problems.

Eye Movement Perimetry: assessment of visual field responsiveness

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Abstract
Standard Automated Perimetry (SAP) is considered to be the gold standard for functional visual field testing. It has been widely used for several decades for the diagnosis and management of different diseases presenting with visual field defects, such as glaucoma, optic neuritis and Retinitis Pigmentosa. When undergoing SAP, subjects are required to sustain a steady central fixation which might result in Ganzfeld blank out or Troxler's fading effect due to neural adaptation. This often leads to complaints such as blurred vision, diplopia, inattention, discomfort, hallucination and fatigue. In addition, the fixation requirement contradicts the natural urge of the subject to look at new peripheral stimuli, thus complicating the task. Eye Movement Perimetry (EMP) addresses some of these concerns. The test allows natural human reflexes to the tested locations while gaze is measured using eye-tracking technology. In the center of the monitor, a central stimulus remains lit during the exam at a background luminance of 150 cd/m^2. The peripheral stimuli (equivalent Goldman size III) are presented at four different brightness levels (ranging from 190 cd/m^2 to 276 cd/m^2). The stimulus grid contains the same 54 locations of the 24-4 SAP grid allowing a pointwise comparison between SAP and EMP. To map the extent of visual field, the binary responses (seen/unseen) for each tested location is used, as in SAP. However, in EMP the Saccadic Reaction Time (SRT) to all seen locations can be derived to map the visual field responsiveness as well, including the subject's oculomotor system properties.

A well-known eye condition that affects the visual field is glaucoma. To date, the global prevalence of glaucoma is 64.3 million which is predicted to increase by 18% in 2020 and 74% in 2040. In our effort to develop EMP into a clinical (screening) tool, first healthy subjects between 20-70 years old underwent a complete ophthalmic examination and an EMP test. We demonstrated good test-retest repeatability (on average the differences were within 100 ms), SRT significantly dependent on age, stimulus intensity and eccentricity (not on gender). At the lowest stimulus intensity of 190 cd/m^2, a significant interaction was found between age and eccentricity (Mazumdar et al., 2019). Next, we investigated the relationship between visual field sensitivity (SAP) and responsiveness (EMP) in patients with cataract (Thepass et al., 2015) and patients with mild, moderate and severe glaucoma. Interestingly, at locations where no sensitivity loss was detected, lengthened SRTs were already detected in all stages of glaucoma compared to healthy controls. This might relate to a "generalized reduction in visual field responsiveness" prior to a "localized decline in sensitivity". Finally, an EMP screening grid was developed that consisted of 26 locations predominantly testing nasal, superior and inferior areas of the visual field. An internal validation of the modified grid showed

90.4% of screening accuracy and it compared well with FDP in terms of speed and diagnostic accuracy (Kadavath Meethal et al., 2019). Elderly healthy participants and patients with moderate and severe glaucomatous defects preferred EMP as it resembled a real-life test setting. Overall, we conclude that EMP may be a potential approach for population based visual field screening.

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Use of VR in Maritime Education and Training

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Abstract

From the low-realistic simulators more than half a century ago to today's full-featured simulators – simulation technology has a long history in maritime training. The efficiency of the simulators is increasing with the technological advancements, and the implementation of head-mounted display virtual reality (HMD VR) systems has become the focus of research in the past decade. The VR market is expected to grow to 90 billion USD by the year 2023 (Digi-Capital, 2019). There are many studies on display types, but the studies on the usefulness of HMD VR systems in training are insufficient. This research will fill this gap by studying the effect of HMD VR on knowledge acquired, and intrinsic motivation, during training. Research literature related to simulator training has consistently indicated increase in motivation during exercises, due to simulators offering fidelity and realism comparable to real life scenarios. Higher motivation levels in trainees have been traditionally associated with increased performance and training satisfaction. VR technology is able to provide more immersive and realistic experiences in simulation applications. The present study aims to better understand and evaluate differences in intrinsic motivation among trainees performing identical tasks utilizing two different simulation platforms – (i) a traditional desktop computer configuration and (ii) a VR Head-Mounted Display (VR HMD). We compared the difference in motivation between the two platforms with 52 participants, using a between group experimental design. Motivation for learning was measured through an intrinsic motivation questionnaire employing six subscales of intrinsic motivation, as well as an exit interview. Results revealed that motivation was higher for participants completing the simulation tasks in the VR HMD group compared to the traditional desktop configuration. These findings suggest that higher immersivity of VR HMDs can increase intrinsic motivation within trainees. This study contributes to the increasing empirical evidence supporting the usefulness of emerging Virtual Reality technologies and their application in simulators for education and training.

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Using VR to study navigation and 3D visual perception in freely moving observers

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Abstract

Historically, much of vision research has used static observers, often with stationary eyes. Virtual reality allows an entirely different set of questions to be asked about vision, including how people navigate and represent a 3D scene as they move. I will describe experiments from our lab which show that the type of representation observers generate when they move is unlikely to be a stable, 3D reconstruction. Instead, observers appear to use representations that allow them to move from one image to another to achieve their goals. The experiments include judging the location of objects in a room that expands around the observer without the observer noticing; pointing to objects that are currently out of view (where we find large, systematic biases); and navigating and pointing to previously-viewed objects in impossible mazes (impossible because the maze changes shape as the observer moves through it). Taken together, the results show that participants behave in reliable and explicable ways. However, the heuristics they use to achieve this do not rely on a stable reconstruction of the scene.

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Immersive virtual reality and presbyopia

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Abstract

With affordable and easily accessible devices, immersive technologies are increasingly becoming more widely used. Although so far mostly used for entertainment, immersive technologies have become more and more relevant in the workspace due to the opportunities for education and training purposes, and within communication and collaboration, amongst others. Immersive technologies are also becoming more useful in activities promoting physical and mental health in senior persons. While exciting, this calls for understanding what impact using immersive technologies has on vision, and to what extent vision problems impact on the usability and efficiency of using immersive technologies. In immersive systems with displays presenting separate visual input to the two eyes to produce a stereoscopic image, the visual system is challenged with the potential of disturbing the cooperation between the two eyes. The decoupling of the accommodation and vergence systems has been a longstanding concern, and recent research has suggested that there are short-term adaptations in the visual system in young adults after using virtual reality, which may give short- or long-term changes. However, little research has been done on persons who are presbyopic, which is a significant group of users likely to increasingly be exposed to immersive technologies. This presentation discusses what implications use of immersive technologies may have on the vision in presbyopic persons and whether one should take precautions when using immersive technologies. The presentation includes discussions on i) how the accommodation-vergence conflict is affected by the loss of accommodation, ii) how oculomotor balance is affected by the loss of accommodation, and to what extent one can expect divergent heterophorias to decompensate, and iii) which focal distance to correct for and which type of corrective lens to aim for. These discussions will be seen in the light of factors such as the type of display, the exposure time, the nature and precision of the task, and the person's need for high quality vision.

Effects of façade and daylight pattern geometry on subjective and physiological responses: findings from experiments in immersive virtual reality

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Abstract

One of the central issues in lighting design is the creation of environments that are both visually stimulating and comfortable (Boyce, 2014; Corrodi & Spechtenhauser, 2008; Van Den Wymelenberg, Inanici, & Johnson, 2010). Following current standards and practices in lighting design, direct sunlight penetration is often restricted in favour of energy savings and visual comfort, leading to luminous environments that have been criticized as being monotonous (Köster, 2004). At the same time, there is a growing use of decorative patterns and permeated walls in contemporary architecture (Corrodi & Spechtenhauser, 2008), which mediate the light that enters a space. Although daylight characteristics such as contrast and luminance variation have been repeatedly linked with impressions of interest in lighting research (Loe, Mansfield, & Rowlands, 1994; Parpairi, Baker, Steemers, & Compagnon, 2002; Rockcastle, Amundadottir, & Andersen, 2017; Rockcastle, Chamilothori, & Andersen, 2017), we have limited knowledge about how the composition of the façade geometry and the resulting daylight patterns affect occupant perception. Existing experimental studies that investigated this topic have employed projected simulated images (Abboushi, Elzeyadi, Taylor, & Sereno, 2019; Omidfar, Niermann, & Groat, 2015), which have been shown to be problematic in replicating the pleasantness and the distribution of light of real environments (Cauwerts, 2013) and thus restrict the applicability of research outcomes. This talk presents findings from a series of experimental studies that systematically examined the impact of façade and daylight pattern geometry on human subjective and physiological responses with a total of over 350 participants, using a novel experimental method which combines immersive virtual reality (VR) with physically based renderings. For the evaluation of perceptual impressions such as the pleasantness or interest of a space, this method has been validated against real daylit environments and has been demonstrated to be suitable for examining such attributes (Chamilothori, Wienold, & Andersen, 2019b). Using this method, we conducted a series of experimental studies where participants were immersed in interior scenes with varying lighting conditions and façade geometry variations of an equal aperture ratio, employing façade designs derived from existing examples of contemporary architecture. These studies demonstrated that the spatial characteristics of façade and daylight patterns influence the perception of the same space (Chamilothori, 2019; Chamilothori, Chinazzo, et al., 2019; Chamilothori, Wienold, & Andersen, 2016), with effects that were robust to changes in the features of the space or the country where the experiment was conducted (Chamilothori, 2019). Moreover, the geometric composition of the façade and the resulting daylight pattern was shown to affect not only the perception, but also the heart rate of participants. In particular, when participants were immersed in an interior scene with direct sunlight and a façade with non-uniformly distributed openings, they rated the space as more interesting and their heart rate was lower compared to when they were immersed in the same scene with horizontal stripes applied to the window (Chamilothori, Chinazzo, et al., 2019).These findings have important implications for the fields of architecture and lighting, demonstrating that façade elements and their interaction with light have a quantifiable effect on occupants and motivating further research in this field. While in general the applicability of VR is limited to specific attributes of visual perception due to its dynamic range, the presented work delineates a particularly promising area of investigation, where immersive environments can be coupled with controlled visual stimuli, questionnaires, and biometric feedback to broaden our understanding of the complex effects of light on humans.

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Virtual test beds for sustainable urban strategies. Universal design in nocturnal cityscapes

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Abstract

Our lighting design students need tools to grasp light phenomena in other ways than traditional lectures or examining images will provide, especially when it comes to urban scenes or urban environments. Recognizing the fact that full scale lighting try-outs in Kongsberg City are the most preferable and yet the hardest to achieve, other ways of testing universal design on such a large scale are required. Virtual environments might give us a much-needed supplement.

Our students are taught to design and establish understandable and engaging nocturnal night-urban light spaces, and sustainability and health benefits are constantly the benchmarks of their projects. Another element we stress is universal design. We look at universal design as a strategy for designing light spaces where no one is discriminated.

As a preliminary test we are about to introduce VR in two courses: Urban Lighting Design in 2nd year and Visual Ergonomics and Universal Design in 3rd year.

The presentation is an introduction to some of the cases and phenomena we use in VR environments, and a discussion of feasibility. The work is based on group work by students in 3rd year and observations and assessments done by the lecturers in both courses.

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Controlled experiments for uncontrolled daylight. VR as a research tool for daylighting design studies

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Abstract

In times when sustainability is on the agenda for most professionals working with architecture and zero emission buildings, pressure rises for the lighting community. This is not surprising when windows have been identified to be responsible for about 30% of the heat loss of a building. However, decreasing windows size on an energy efficiency basis can be counterproductive in the long term. Research has found that windows provide many benefits that range from having a connection to an outside view, avoidance of claustrophobia, boredom and feelings of monotony, and knowledge of weather and time of the day. These are, among others, important aspects for humans when inhabiting a built space. Hence, the response of the lighting community should be responsible in terms of energy-efficiency, while at the same time complementing the architectural design in maintaining lighting quality.

Yet, when designing the size of building openings in Norway, daylighting design mostly consider a 2% daylight factor (D) as rule of thumb to comply with the current regulations (Direktoratet for byggkvalitet, 2017). However, it is important to remember that the D accounts for overcast sky conditions only. Although a large window can easily provide much more than the minimum of 2% D, the same window under clear and sunny sky conditions can produce overheating and glare. Thus, there is a need to test the users' acceptance of window size considering other factors, such as different sky types.

The importance of conducting precise and rigorous scientific research in the field of daylight and its impact on the visual quality of architecture encounters challenges for most researchers. Most of these challenges seem to involve logistical

issues, economic resources, time consumption during experiments and a variety of spatial characteristics that one wishes to investigate. Moreover, daylight is unpredictable by nature and cannot be controlled. The constant fluctuations of natural light bring difficulties to researchers in attaining control in experiments. Many researchers are often unable to do research in the field of daylighting in full scale, due to the demanding process of attaining control over these challenges. Even if they do, the experimental design can be rather limited.

In order to perform architectural research within the daylighting field, without encountering the problems listed above, simulation methods have been used in the past. Slides, scale models and stereoscopic images have been used with promising results (Moscoso, Matusiak, Svensson, & Orleanski, 2015). Yet, more truthful representations of real environments are needed to offer a realistic experience to experiment participants. To this end, virtual reality (VR) has been confirmed as an adequate research tool for daylighting studies (Chamilothori, Wienold, & Andersen, 2019a).

The presentation will discuss subjects such as the use of VR to overcome experimental challenges when dealing with daylight. Furthermore, results from an experimental study with different factors such as window size and sky types using VR as a tool will be also discussed, in which the impact of window size on users' spatial perception will be presented.

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The use of VR technologies to enhance methods for lighting design practice

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Abstract

Contemporary architecture, engineering and construction practices primarily use virtual reality (VR) either as a means for communication between the different disciplines, co-design, or as a presentation medium, that gives users as well as clients a human-scale experience of a project (Angulo & de Velasco, 2014). This situation also applies to the field of lighting design, creating a situation where the only area of the lighting design process not influenced by VR, is the area of the design itself. Ideally, lighting is designed within the context of a physical space, allowing a more accurate rendition and perception of how light influences its surroundings and the ability to convey the effects of spatial lighting similar to how humans would perceive them. However, such an approach to visually representing light in the earlier stages of the design is not currently possible. This presentation describes the development and testing of an immersive VR tool for the development of lighting design at a 1:1 scale in a real-time virtual environment (VE). While the project's results are limited due to its proof-of-concept development stage, the responses from the participants indicate that the tool is advantageous in the design development as well as the design communication phases. The VR tool described allows for more design iterations and experiments, better perception of spatial lighting effects, better representation of lighting at a 1:1 scale from a human perceptual perspective, and allows the lighting designer an opportunity to become an actor in the space rather than an observer behind a screen.

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