Researchers' and Participants' Experiences on Distributed User Studies Conducted in the First Year of COVID-19 Pandemic

ANIL UFUK BATMAZ, Simon Fraser University, Canada

DOMENICK MIFSUD, Colorado State University, USA

ANTHONY STEED, University College London, United Kingdom

WOLFGANG STUERZLINGER, Simon Fraser University, Canada

FRANCISCO R. ORTEGA, Colorado State University, USA

COVID-19 has raised significant challenges to the conduct of Virtual Reality (VR) and Augmented Reality (AR) studies. Previously, most VR and AR academic research happened in research labs at universities, where the experiments were conducted in controlled environments with specific installations and instrumentation. With the ongoing pandemic, many VR/AR researchers switched by necessity to distributed studies, where the participants participate in the studies from their own living or working spaces. This change created novel challenges for participants and experimenters. In this paper, we report some experiences with VR/AR studies conducted in the first year of COVID-19 and present recommendations for future, distributed VR/AR studies.

CCS Concepts: • **Human-centered computing** → **User studies**; **Virtual reality**.

Additional Key Words and Phrases: Virtual Reality, Augmented Reality, Distributed Experiments, User Experience, User study

1 INTRODUCTION

Until the first months of 2020, Virtual Reality (VR) and Augmented Reality (AR) researchers performed most of their experiments on-site, e.g., in their laboratories, typically at universities (or commercial research labs). When the COVID-19 pandemic imposed restrictions on such research studies, researchers had to make fundamental changes to how they conduct user studies, typically by distributing and remotely conducting them. However, this change also revealed problems that had rarely been experienced before by laboratories and researchers focused on VR/AR research.

There are several reasons why researchers preferred to conduct VR/AR studies in labs before the pandemic started. For instance, researchers can there easily instruct and monitor participants, gather other data such as video footage, ask participants questions during debriefing, and perhaps most importantly can ensure that participants safely comply with the experimental protocol (and manage deviations from it). While asking people to use their own VR hardware is a

Authors' addresses: Anil Ufuk Batmaz, Simon Fraser University, Canada, abatmaz@sfu.ca; Domenick Mifsud, Colorado State University, USA; Anthony Steed, University College London, United Kingdom; Wolfgang Stuerzlinger, Simon Fraser University, Canada; Francisco R. Ortega, Colorado State University, USA.

potential option, at the global level it is still rare to see modern VR hardware in a household. After all such hardware is only affordable for some, and only in a limited number of countries of the world.

After the COVID-19 pandemic started, researchers had to overcome the challenges associated with setting up distributed VR/AR studies. One prominent example is that it is difficult to distribute novel hardware to participants and to retrieve it reliably after a study. Since many VR/AR hardware interaction studies are based on prototype devices and the fact that it requires substantial time, effort, and money to distribute/retrieve such hardware, researchers saw it as more opportunistic to conduct the studies inside their labs. The logistics of sending hardware, e.g., safely packaging, and tracking the shipments, usually motivated researchers not to consider conducting distributed experiments. Especially during the COVID-19 pandemic, the logistics became more challenging, as people generally depended much more on postal services for online shopping, which also meant that the volume of shipments (and thus the potential for loss) increased substantially. Additionally, the challenge of requiring (naive) participants to correctly set up research prototype hardware is not to be underestimated.

During this chaotic period, distributed interactive VR/AR studies had to face various challenges that were never discussed broadly before. Researchers and developers focused on potential solutions, such as gathering and discussing virtually, and planning ahead. However, the COVID-19 pandemic has now lasted for more than a year, and has already changed how the community is conducting distributed VR/AR experiments. This paper aims to report some of the most salient experiences of participants and researchers and to also provide insights for future distributed VR/AR studies.

2　EXPERIENCES OF RESEARCHERS, OBSERVERS, AND EXPERIMENTERS

Since distributed experiments are conducted remotely, participants have to manually sign up and also need have set up their own VR/AR system. This process is not supervised by the experimenter, and due to privacy restrictions, the experimenter cannot connect directly to the participants' computer nor physically set up the experiment. This creates delays in the conducted study, e.g., to check tracking accuracy, which expands the time needed for any experiment. This can lead to user frustration that might affect the results.

For practical reasons, including injury prevention, any experiment should be (largely) agnostic to the participants' space configuration, which favors "seated VR" experiments. Making an experiment self-contained, self-instructional, carefully controlled, and robust is also highly advisable, including data logging and the informed consent process.

One of the major problems experienced by experimenters in distributed VR/AR studies was issues with lighting. Most VR/AR trackers use infrared sensors that are susceptible to sunlight. Thus, it was (much) easier in the past to conduct VR experiments in a controlled lab environment, where the source of the light could be adjusted according to the needs of the tracking system. However, this kind of control is not feasible in distributed experiments.

Another related issue is finding participants that own an AR headset. While VR headsets are starting to be more common in households, AR HMDs are still not as affordable as VR headsets. This limits the number of participants available for any AR experiment. Also, the display quality of an AR HMD is (much) affected by the brightness of the surrounding environment, which directly affects the visual feedback provided by an AR system. The lack of controlled lighting (as mentioned above) is thus a major issue for distributed AR experiments.

Researchers also aware that building complex experiments for remote studies, and making them reliable is extremely time-consuming. Additional features, such as preparing the documentation for experimental steps require further time during the experiment preparation. This leads to researchers favouring simple experiments over complex ones.

Rapid changes in COVID-19 trends in different regions of the world can directly impact participants. E.g., a newly imposed COVID curfew can make it impossible for a participant to travel to another location in the same city, e.g., at

their workplace, where they might have had access to a VR/AR headset. In such cases, experimenters have no choice but to postpone or cancel the experiment.

3 EXPERIENCES OF SUBJECTS, PARTICIPANTS, AND VOLUNTEERS

A reliable internet connection is an important requirement for many distributed VR/AR systems. In a distributed experiment, participants' can become frustrated with varying internet speeds, e.g., due to the time required to establish all connections necessary for an experiment or to to upload log files to servers at the end.

Guaranteeing physical security and data privacy during COVID-19 are two major challenges that are still not addressed well by the research community. Due to privacy or other reasons, some participants cannot be adequately supervised, i.e., lacking live audio or video connection to monitor participants during the experiment. In this case, the experimenter cannot assist a participant, e.g., to solve tracking issues or to warn them before they hit a lamp. Such cases could affect the user performance and the experience within the conducted study.

Recently, some countries started to impose further restrictions on their population to decrease the impact of COVID-19, such as asking people to stay in their households on weekends or after work hours. This led to people starting to use their home internet more than usual, which resulted in a decrease of the average internet connection speed. This can affect the communication between the participant and experimenter within a supervised experiment.

Another set of challenges for conducting distributed experiments is related to geographic differences between locations, such as time zonesIn multi-user experiments, participants can be matched with people around the world, where one of the participants have to sacrifice their rest time. While such differences already had an impact in the past, they became potential barriers for distributed studies after the COVID-19 pandemic started.

4 OVERVIEW AND THE (UN)EXPECTED FUTURE

COVID-19 significantly impacted our social and private life. Most researchers had to abandon their laboratories and started working from their homes. The global pandemic has thus had a strong impact on the type and volume of AR/VR studies that can be performed. In some areas the forced move to distributed experiments has helped researchers to improve their methods, e.g., developing better in-system data logging and using more robust experimental protocols. Also it has enabled access to larger participant pools, compared to typical student populations.

At this point, it is difficult to plan for the future. However, we suggest researchers prepare themselves for two different potential futures. The first one is that the impact of the COVID-19 pandemic could last for several more years, e.g., if vaccines are not effective or roll-outs are delayed. Researchers should thus prepare themselves for the corresponding limitations and restrictions that might arise (again). This includes but is not limited to, novel security and privacy legislation, distribution challenges through postal services, and also lack of networking between researchers, which can disproportionately impact junior people. Also, the impact of COVID-19 on individuals and focused user groups should to be monitored, to inform researchers on how to provide reliable experimental setups to participants.

A second potential future is the best-case scenario, where the COVID-19 pandemic ends as soon as possible. Then, the current challenges will likely disappear. Still, even in this case, researchers need to acknowledge that people who were working from home will (again) have to change their daily routine(s). This will still impact the participants and thus also future user studies.

Overall, we are planning to gather more information regarding how COVID-19 affected our research field and provide further suggestions to improve distributed experiments for both researchers and participants. We believe that these suggestions can help the community to conduct safe, reliable, and secure experiments.