



# CSMEN – Simulation Publications Update

## November 2020 Bulletin

### Technology Enhanced Learning in Simulation

#### Welcome

Welcome to the Simulation Publications Update a service brought to you by CSMEN in partnership with NES Knowledge Services.

The focus for this Simulation bulletin is on how technology can be used in simulation based education. These articles may be of interest or relevance to your current role in NHS Scotland. The articles may also be of use in your research. These articles are from those journals we currently subscribe to. If there are any articles or journals that you would like us to add/consider please let us know.

Until now we have tried to provide approximately 30 links to articles on all aspects of simulation. We are now moving to shorter bulletins focusing on different aspects of simulation.

The articles identified VR, gaming or other forms of technology to enhance learning through simulation. The wide diversity of the use of TEL shows how simulation can be used alongside other types of TEL to prepare the workforce and in testing new systems in organisations.

If you would like to suggest a focus topic or become a reviewer, please also let me know.

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The plan is to widen this service to focus on topic areas and to monitor its use and effectiveness so feedback would be much appreciated.

This bulletin has been developed by Jean Ker clinical lead CSMEN in partnership with Alan Gillies from NES Knowledge Services.

#### Access to journals

Different journals have different processes for login so please follow the instructions for accessing the full text of the articles through the links provided.

On your behalf NES Knowledge Services subscribes to some journals direct and others via aggregators (i.e. journal collections or full text databases). We use something called a 'link resolver' to link you via the best route using your NHS Scotland OpenAthens password.

Some journals can detect that you're logging in from NHS premises, so won't ask for the OpenAthens password, but if you're accessing from home you may have to login.



None of the links should require you to set up a separate login – where there are login boxes for personal accounts, look for an OpenAthens or ‘institutional login’ option as well, which will accept your OpenAthens password.

### Focus: TEL in Simulation based Education

[Cultivating empathy through virtual reality: Advancing conversations about racism, inequity, and climate in medicine.](#) Roswell R.O., et al, Academic Medicine: Journal of the Association of American Medical Colleges, 2020.

There are several very interesting papers in this bulletin including the use of pauses to impact cognitive load in a gaming environment; the use of VR to track skill decay and the use of tele-mentoring with augmented reality in remote and rural practice. I chose this one for its subject matter – the use of VR in cultivating empathy.

The paper in fact evaluates the utility of integrating a racism focused VR experience into a learning package as part of a long term approach by an American Medical College to reduce racism and bias in staff and faculty recognising how they can negatively impact on the College learning environment.

The study was developed around evidence of the need to improve cross cultural communication and enhance inclusion as strategic priorities of the institution. VR has been shown to be an important tool in promoting empathy (*Herrera F, Bailenson J, Weisz E, Ogle E, Zaki J. Building long-term empathy: A largescale comparison of traditional and virtual reality perspective-taking. PLoS ONE. 2018;13, e0204494*)

The focus of this study was engaging 112 staff and faculty as part of professional development on a 2 day learning package to enhance cross cultural communication and inclusion. Participants attended a session on microaggression and then participated in an individual VR 1000 cut journey (<https://vhil.stanford.edu/1000cut/>) where they became Michael at different stages of his life experiencing racism. They then attended a debriefing session.

The study used a survey instrument and a presence questionnaire which explored both presence and engagement in the VR. This was the most disappointing aspect of the study in that improvements in empathy were self reported indirectly through feeling both present (60.5%) in the VR experience and engaged (90.8%).

67.1% suggested they would change their cross cultural approach to communication. There was no analysis across the diverse group of who had made the greatest shift and no assessment of pre-intervention of empathy levels. However, it did demonstrate the utility of integrating a racism focused VR as part of a learning package.

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**[Virtual reality with three-dimensional image guidance of individual patients' vessel anatomy in laparoscopic distal pancreatectomy.](#)** Aoki T., et al, Langenbeck's Archives of Surgery, Vol 405, 3, 381-389. 2020.

*Three-dimensional virtual endoscopy (3DVE) has the potential advantage of enhanced anatomic delineation and spatial orientation during laparoscopic procedures. The study aimed to evaluate the impact of 3DVE guidance in laparoscopic distal pancreatectomy (LDP). Thirty-eight patients presenting to hospital with a variety of pancreatic tumors underwent preoperative computed tomography scanning to clearly define the major peripancreatic vasculature and correlate it with a 3DVE system. The authors conclude that 3DVE in conjunction with a "laparoscopic eye" creates a preoperative and intraoperative three-dimensional data platform that potentially enhances the accuracy and safety of LDP.*

**[Challenges and practical considerations in applying virtual reality in medical education and treatment.](#)**

Baniasadi T., et al, Oman Medical Journal, Vol 35, 3) Article Number:e125. 2020.  
*This review aimed to determine the challenges associated with the application of VR in the field of medical education and treatment. The main challenges of developing and using VR with educational and therapeutic objectives are categorized as general and specific. General challenges include reduced face-to-face communications, education, cost challenges, users' attitudes, and specific challenges such as designing, safety considerations, VR side effects, evaluation, and validation of VR applications.*

**[Surgical games: A simulation-based structured assessment of orthopedic surgery resident technical skill.](#)** Blevins J.L., et al, Journal of Surgical Education, 2020.

*Simulation-based education and objective evaluation of surgical skill have been incorporated into many surgical training programs. This article describes the development and implementation of a timed, multitask, station-based Surgical Games to evaluate orthopedic resident surgical skills. The Surgical Games exercise provided an objective evaluation of surgical skill that correlated with year-in-training and prior experience in skill-specific rotations for the KAS, TKA, and CTR tasks. This surgical skills assessment provided an opportunity for effective structured feedback and identification of areas for improvement.*

**[Using virtual human technology in perioperative team training simulations.](#)** Brunges, M. & Hughes, T.E., AORN Journal, 617-626. 2020.

*Incorporating virtual human (VH) technology into simulation programs for perioperative education and training can improve interdisciplinary teamwork and communication. The development of VHs allowed interdisciplinary teams at the University of Florida Health Shands Hospital to overcome obstacles during training, such as communication gaps. Using validated tools to promote standardized communication, participants had to address patient safety concerns assertively during the simulations. After each simulation session, quality specialists conducted a debriefing, collected data via surveys, and identified areas for improvement. As a result of the VH simulation sessions, perioperative staff members reported increased confidence and competence when providing patient care.*

**[Simulation training using WhatsApp \(sim-thru-WhatsApp\) improves doctors' confidence in endocrine and diabetes case management.](#)** Chen, W., et al, Clinical Medicine, s62-s63. 2020.

*The aim of Sim-thru-WhatsApp is to create a feasible and cost-effective SBL model in medical education. This study was conducted as part of the continuous professional development for Health Education West Midlands specialty trainees in diabetes and endocrinology. Twenty-four and 17*



*trainees participated in an endocrine and diabetes simulation respectively. Sim-thru-WhatsApp proved to be an effective teaching model, with a high acceptance rate, which improved doctors' confidence in managing endocrine and diabetes cases.*

**Enhancing reality: A systematic review of augmented reality in neuronavigation and education.** Cho J., et al, World Neurosurgery, Vol 139, 186-195. 2020.

*Augmented reality (AR) is increasingly being explored as an adjunct to conventional neuronavigation systems. AR affords the ability to superimpose 3-dimensional images onto the real environment. This article reviews the literature on the use of AR in neurosurgery with a focus on current technologies and limitations. The most common use of AR in neurosurgery was in cranial surgery (n = 26). Other uses included spine surgery (n = 9) and education (n = 2). Devices used for display of AR images varied as did image-to-patient registration methods and overall system accuracy. Although various AR systems have been successfully utilized across many neurosurgical disciplines, more research is needed to improve accuracy in registration and to assess whether AR-assisted surgery is safe and effective for widespread adoption.*

**The impact of tiredness on virtual reality robotic surgical skills.** Cumanas A.A., et al, Wideochirurgia I Inne Techniki Maloinwazyjne, Vol 15, 2, 298-304. 2020.

*This study aimed to evaluate to what extent the surgeon's skills are influenced by long procedures, using the objective assessment of different surgical skills by a virtual reality robotic simulator. Fifteen surgeons were asked to perform a continuous 4 h virtual robotic surgical simulator training session. At the beginning of simulator training and at the end of each of the 4 h of training, three exercises of increasing difficulty were selected to be performed in order to assess the surgeons' skills. There were statistically significant differences between the initial and final overall scores for all the three exercises, the final outcomes being inferior. The specific metrics for each exercise slightly improved within 1 h from the beginning and thereafter decreased to a statistically significantly inferior value.*

**Use of role-play simulation to improve nurse practitioner students' case presentation: An innovative educational approach for the distance learner.** Davis, L. & Colella, C., Nurse Educator, 2020.

*One way in which students can practice and refine case presentation skills is through role-play simulation. Educators are increasingly challenged to create new teaching and learning strategies to complement the online classroom. Incorporating pedagogical strategies that aid in refining verbal communication skills prepares the student for the clinical learning experience on a new level. Combining the use of low-fidelity simulation with the SNAPPS technique (a 6-step student-directed learning technique to facilitate case presentations) equips students with a structured approach for case presentation so that the student enters the clinical experience well prepared and engaged.*

**An online, interactive, screen-based simulator for learning basic EEG interpretation.** Fahy, B.G., et al, Neurological Sciences, 2020.

*This study aimed to develop and pilot test a simulator that presents ten commonly encountered representative clinical contexts for trainees to learn basic electroencephalogram (EEG) interpretation skills. An interactive web-based training simulator was created that allows self-paced, asynchronous learning and assessment of basic EEG interpretation skills. The simulator has been used by 76 trainees in total. This article reports pilot study results from the University of Florida's neurology residents (N = 24). The pilot study showed a moderately strong correlation  $r = 0.49$  between the In-training Examination (ITE) and the average scenario score. Since the ITE is a*



*measure of clinical practice, this is evidence that the simulator can provide self-directed instruction and shows promise as a tool for assessment of EEG knowledge.*

**Virtual reality-based cognitive stimulation to improve cognitive functioning in community elderly: A controlled study.** Gamito, P., et al, *Cyberpsychology, Behavior and Social Networking*, 150-156. 2020.

*The advantages of using naturalistic virtual reality (VR) environments based on everyday life tasks for cognitive intervention in the elderly are not yet well understood. The literature suggests that the similarity of such exercises with real life activities may improve generalizability by extending the transfer of gains of training to everyday living. This study aimed to investigate the gains associated with this ecologically-oriented virtual reality cognitive stimulation (VR-CS) versus standard cognitive stimulation in the elderly. The results showed positive outcomes on dimensions of general cognition, executive functioning, attention, and visual memory in the group that underwent VR-CS. Improvements in executive functioning was supported by consistent evidence of increases in attention abilities but little evidence of increases in memory abilities. Both effects may have contributed to improvements in general cognition.*

**Conversational therapy through semi-immersive virtual reality environments for language recovery and psychological well-being in post stroke aphasia.** Giachero A., et al, *Behavioural Neurology*, Vol 2020, 2846046.

*Aphasia is a highly disabling acquired language disorder generally caused by a left-lateralized brain damage. The recent application of virtual reality (VR) to aphasia rehabilitation has already evidenced its usefulness in promoting a more pragmatically oriented treatment than conventional therapies. In this study, thirty-six chronic persons with aphasia were randomly assigned to two groups – a VR group and a control group trained in a conventional setting without VR support. After the treatment, no significant differences among groups were found in the different measures. However, the amount of improvement in the different areas was distributed over far more cognitive and psychological aspects in the VR group than in the control group. The within-group comparisons showed a significant enhancement in different language tasks (i.e., oral comprehension, repetition, and written language) only in the VR group. Significant gains, after the treatment, were also found, in the VR group, in different psychological dimensions (i.e., self-esteem and emotional and mood state).*

**Virtual reality applications toward medical field.** Javid M. & Haleem, A., *Clinical Epidemiology and Global Health*, Vol 8, 2, 600-605. 2020.

*This literature review finds that medical professionals are developing and implementing VR technology for training, diagnosis and virtual treatment. It identifies fourteen major applications of VR in the medical field.*

**Effectiveness of virtual reality- and gaming-based interventions for upper extremity rehabilitation poststroke: A meta-analysis.** Karamians, R., et al, *Archives of Physical Medicine & Rehabilitation*, 885-896. 2020.

*This analysis aimed to investigate the efficacy of virtual reality (VR)- and gaming-based interventions for improving upper extremity function poststroke, and to examine demographic and treatment-related factors that may moderate treatment response. Thirty-eight articles met the inclusion criteria. On average, VR or gaming interventions produced an improvement of 28.5% of the maximal possible improvement. Dose and severity of motor impairment did not significantly influence rehabilitation outcomes. Treatment gains were significantly larger overall (10.8%) when*



*the computerized training involved a gaming component vs just visual feedback. VR or gaming interventions showed a significant treatment advantage (10.4%) over active control treatments.*

**[Different effects of pausing on cognitive load in a medical simulation game](#)**, Lee, J.Y., et al, Computers in Human Behavior, Vol 110, 2020.

*In medical training, allowing learners to take pauses during tasks is known to enhance performance. However, empirical studies on how allowing and taking pauses affects cognitive load and performance in dynamic task environments are scarce. This study investigated the pause effect, using a computerized simulation game in emergency medicine. Medical students were randomly assigned to one of two conditions: simulation with (n = 40) and without (n = 30) the option to take pauses. Overall, both cognitive load and performance were higher in the condition with pauses than in the one without. The act of pausing, however, temporarily lowered cognitive load, especially during intense moments. The authors argue that the results suggest that in order to enhance students' performance and learning it is important that we encourage them to utilize the different effects of pausing.*

**[Using virtual reality-based training to improve cognitive function, instrumental activities of daily living and neural efficiency in older adults with mild cognitive impairment](#)**. Liao, Y., et al, European Journal of Physical & Rehabilitation Medicine, 47-57. 2020.

*combination of physical and cognitive training appears to be an effective intervention to improve cognitive function in older adults with mild cognitive impairment (MCI). Computing technology such as virtual reality (VR) may have the potential to assist rehabilitation in shaping brain health. This study investigated the effects of 12 weeks of VR-based physical and cognitive training on cognitive function, brain activation and instrumental activities of daily living (IADL) and compared the VR intervention with combined physical and cognitive training. Both intervention and control groups showed improved executive function and verbal memory (immediate recall). However, only the VR group showed significant improvements in global cognition, verbal memory (delayed recall), and IADL after the intervention.*

**[Improved complex skill acquisition by immersive virtual reality training: A randomized controlled trial](#)**.

Lohre R., et al, Journal of Bone and Joint Surgery - American Volume, Vol 102, 6, 18 Mar 2020. *The purpose of this multicenter, blinded, randomized controlled trial was to determine the validity and efficacy of immersive VR training in orthopaedic resident education. Nineteen senior orthopaedic residents (resident group) and 7 consultant shoulder arthroplasty surgeons (expert group) participated in the trial comparing immersive VR with traditional learning using a technical journal article as a control. Immersive VR demonstrated substantially improved translational technical and nontechnical skills acquisition over traditional learning. Additionally, the results demonstrate the face, content, construct, and transfer validity for immersive VR.*

**[Demonstrating the effectiveness of the fundamentals of robotic surgery \(FRS\) curriculum on the RobotiX mentor virtual reality simulation platform](#)**. Martin J.R., et al, Journal of Robotic Surgery, 2020.

*Fundamentals of robotic surgery (FRS) is a proficiency-based progression curriculum developed by robotic surgery experts from multiple specialty areas to address gaps in existing robotic surgery training curricula. The RobotiX Mentor is a virtual reality training platform for robotic surgery. The aims of this study were to determine if robotic surgery novices would demonstrate improved technical skills after completing FRS training on the RobotiX Mentor, and to compare the effectiveness of FRS across training platforms. Robotic surgery novices (n = 20) were enrolled and*





*trained to expert-derived benchmarks using FRS on the RobotiX Mentor. The findings provide validity evidence for FRS and support use of the RobotiX Mentor for robotic surgery skill acquisition.*

**Can virtual reality be used to track skills decay during the research years?** Mohamadipanah, H., et al, Journal of Surgical Research, 150-155. 2020.

*Time away from surgical practice can lead to skills decay. Research residents are thought to be prone to skills decay, given their limited experience and reduced exposure to clinical activities during their research training years. This study takes a cross-sectional approach to assess differences in residents' skills at the beginning and end of their research years using virtual reality. The findings of increased "tracking error" among residents at the end of their research time suggests fine psychomotor skills decay in residents who spend time away from clinical duties during laboratory time. This decay demonstrates the need for research residents to regularly participate in clinical activities, simulation, or assessments to minimize and monitor skills decay while away from clinical practice.*

**Utilizing telepresence robots for multiple patient scenarios in an online nurse practitioner program,** Mudd, S.S., et al, Nursing Education Perspectives, Vol 41, 4, 260-262. 2020.

*Simulation has been utilized widely in nurse practitioner programs for competency development and training. With the growing number of online educational programs, innovative solutions need to be developed to assess student competency for a variety of clinical situations and scenarios. An innovative method is the implementation of telepresence robots for multiple patient scenarios in a simulated environment. This article demonstrates the use of multiple patient scenarios using telepresence robots in an online post master's acute care pediatric nurse practitioner program.*

**The system for telementoring with augmented reality (STAR): A head-mounted display to improve surgical coaching and confidence in remote areas.** Rojas-Munoz, E., et al, Surgery, 724-731. 2020.

*The surgical workforce particularly in rural regions needs novel approaches to reinforce the skills and confidence of health practitioners. The benefits of platforms of augmented reality-based telementoring in the coaching and confidence of medical personnel are yet to be evaluated. In this study, 20 participants were guided by remote expert surgeons to perform leg fasciotomies on cadavers under one of two conditions: (1) telementoring (with our System for Telementoring with Augmented Reality) or (2) independently reviewing the procedure beforehand. Participants using the System for Telementoring with Augmented Reality received 10% greater Weighted Individual Performance Score ( $P = .03$ ) and performed 67% fewer errors ( $P = .04$ ). In addition, participants using the System for Telementoring with Augmented Reality reported being more confident when performing fasciotomies under telementoring. Augmented Reality Head-Mounted Display-based telementoring successfully provided confidence and coaching to medical personnel.*

**Cultivating empathy through virtual reality: Advancing conversations about racism, inequity, and climate in medicine.** Roswell R.O., et al, Academic Medicine : Journal of the Association of American Medical Colleges, 2020.

*In 2019, the Zucker School of Medicine and Northwell Health piloted a virtual reality (VR) racism experience as a component of professional development for medical school and health system leaders, faculty, and staff. Participants experienced a 60-minute, interactive, large-group session on microaggressions and, as individuals, a 20-minute VR module. These were followed by group reflection and debriefing. In October 2019, in a post-workshop survey, completed by 76 participants (67.9%), most respondents (90.8%) reported feeling engaged in the VR experience. Additionally, the majority agreed that VR was an effective tool for enhancing empathy (94.7%), that the session*



*enhanced their own empathy for racial minorities (85.5%), and that their approach to communication would change (67.1%). In open-ended responses, participants frequently conveyed enthusiasm, powerful emotional and physiologic responses, and enhanced empathy. They also suggested more time for follow-up discussions.*

**[Improving the quality of evaluation data in simulation-based healthcare improvement projects: A practitioner's guide to choosing and using published measurement tools.](#)** Santomauro, C.M., et al, Simulation in Healthcare: The Journal of the Society for Medical Simulation, 2020.

*Simulation is increasingly being used in healthcare improvement projects. The aims of such projects can be extremely diverse so the outcomes or participant attributes that need to be measured can vary dramatically and may include a wide range of nontechnical skills, technical skills, and psychological constructs. Consequently, there is a growing need for simulation practitioners to be able to identify suitable measurement tools and incorporate them into their work. This article provides a practical introduction and guide to the key considerations for practitioners when selecting and using such tools. It also offers a substantial selection of example tools, both to illustrate the key considerations in relation to choosing a measure (including reliability and validity) and to serve as a convenient resource for those planning a study.*

**[Introducing augmented reality technology to enhance learning in pharmacy education: A pilot study.](#)**

Schneider J., et al, Pharmacy, Vol 8, 3, Article No:109. 2020.

*The purpose of this study was to develop an augmented reality (AR) tool and investigate its effectiveness for learning about the medication naloxone using AR in a MagicBook; and determine student opinions on its acceptability and usability. 25 undergraduate pharmacy students were recruited to participate in the study. Pre-and post-tests were used to measure changes in knowledge and a survey was used to collect information on the usability and acceptability of AR for learning. The findings of the study indicated that AR technology was able to support student learning on the chosen topic, showing 42% improvement in a quiz score, and that students found using AR was stimulating, interactive, engaging and easy to follow.*

**[Significant applications of virtual reality for COVID-19 pandemic.](#)** Singh, R.P., et al, Diabetes & Metabolic Syndrome, 661-664. 2020.

*A brief review on Virtual Reality and its applications for the COVID-19 pandemic was carried out by employing keywords as Virtual reality or VR and COVID-19 from the following databases: SCOPUS, Google Scholar, PubMed, Web of science Academia and ResearchGate. It indicates that VR is beneficial for remote sites for exploring telemedicine, planning, treatment, and controlling of the infections by providing proper awareness to the people regarding this disease.*

**[Simulations and virtual learning supporting clinical education during the COVID 19 pandemic.](#)**

Tabatabai, S., Advances in Medical Education & Practice, Vol 11, 513-516. 2020.

*This commentary explores how COVID-19 has challenged medical education. It also discusses the future implications and potential challenges of incorporating simulation-based virtual learning technologies into the medical curriculum, for the future of clinical education, and students' or residents' competency evaluation.*

**[Transition to online is possible: Solution for simulation-based teaching during the COVID-19 pandemic,](#)**

Torres, A., et al, Medical Education, Vol 54, 9, 858-859. 2020.

*The article addresses the problem of how to convert a simulation-based course in geriatrics into distance learning after Polish universities suspended all on-site activities in March 2020 due to the*





coronavirus disease 2019 (COVID-19). Topics discussed include the resulting on-line simulation environment, possibility of preservation of functional and psychological resemblance to on-site conditions, and barriers that could be overcome by proper faculty member and simulated patient (SP) training.

**Augmented reality in surgical training: A systematic review.** Williams M.A., et al, Postgraduate Medical Journal, 2020.

*The aim of this systematic review is to provide an update on the current state of augmented reality (AR) in surgical training and to further report on any described benefits compared with traditional techniques. The systematic search returned a total of 236 results, of which 18 were selected for final inclusion. Studies covered the full range of surgical disciplines and reported on outcomes including operative duration, accuracy and postoperative complication rates. Due to the heterogeneity of the collected data, no meta-analysis was possible. Outcome measures of competency, surgical opinion and postoperative complication rate were in favour of AR technology while operative duration appears to increase.*

**Virtual reality simulation increases Chinese physicians' and lab technicians' familiarity and confidence regarding proper clinical wastes segregation/disposal: A 2-year pilot study,** Wu, S., et al, BMJ STEL, bmjstel-2019-000554. 2020.

*Although they receive regular training, a survey administered to junior physicians and lab technicians revealed that they lack familiarity and confidence regarding the proper segregation/disposal of clinical wastes. In this pilot prospective study, researchers developed a virtual reality (VR) simulation and integrated it into the steps of Gagen's training flow. Initial positive results indicated the possibility of applying this VR game-based simulation system to regular institution-wide staff education in future.*

**Impact of an immersive virtual reality curriculum on medical students' clinical assessment of infants with respiratory distress.** Zackoff M.W., et al, Pediatric Critical Care Medicine, 477-485. 2020.

*This study aimed to determine whether exposure to an immersive virtual reality curriculum on pediatric respiratory distress improves medical students' recognition of impending respiratory failure. A randomized selection of students was exposed to the virtual reality curriculum. All students received standard training on respiratory distress through didactics and high-fidelity mannequin simulation. Intervention students underwent an additional 30-minute immersive virtual reality curriculum, experienced through an OculusRift headset, with three simulations of an infant with 1) no distress, 2) respiratory distress, and 3) impending respiratory failure. Exposure to the immersive virtual reality curriculum led to improvement in objective competence at the assessment of respiratory distress and recognition of the need for escalation of care for patients with signs of impending respiratory failure.*

**Haptic-feedback smart glove as a creative human-machine interface (HMI) for virtual/augmented reality applications.** Zhu M., et al, Science Advances, Vol 6, 19, eaaz8693. 2020.

*Human-machine interfaces (HMIs) experience increasing requirements for intuitive and effective manipulation. Current commercialized solutions of glove-based HMI are limited by either detectable motions or the huge cost on fabrication, energy, and computing power. We propose the haptic-feedback smart glove with triboelectric-based finger bending sensors, palm sliding sensor, and piezoelectric mechanical stimulators. The detection of multidirectional bending and sliding events is demonstrated in virtual space using the self-generated triboelectric signals for various degrees of freedom on human hand. We also perform haptic mechanical stimulation via piezoelectric chips to*



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*realize the augmented HMI. The smart glove achieves object recognition using machine learning technique, with an accuracy of 96%. Through the integrated demonstration of multidimensional manipulation, haptic feedback, and AI-based object recognition, our glove reveals its potential as a promising solution for low-cost and advanced human-machine interaction, which can benefit diversified areas, including entertainment, home healthcare, sports training, and medical industry.*