Carleton University
Information Technology

ITEC 5208 / HCIN 5501 W (0.5 credit)
Virtual and Augmented Reality Technology Winter 2022

Instructor: Dr. Robert J. Teather
Office: AP 230J
Office Hours: Tuesday/Thursday: 2:00 – 2:35pm
Lecture: Tuesday/Thursday: 2:35 – 3:55pm
Location: Online, via Brightspace & Zoom
Email: Rob.Teather@carleton.ca

Course Description:
Research in and design of virtual/augmented reality systems. Applications, history, human factors, display and input hardware, and interaction techniques for navigation, selection and manipulation. Students develop and evaluate a VR/AR system using modern game engines and 3D hardware devices such as head-mounted displays.

Course Objectives/Learning Outcomes:
- Understand 3D interaction techniques, e.g., selection techniques, navigation techniques, etc.
- Describe application areas of VR/AR, including entertainment and others
- Use specialized VR/AR hardware (e.g., head-mounted displays, 3D trackers) to create immersive systems
- Conduct empirical evaluations by experimental comparison of different VR/AR system options

Textbook/Equipment/Material:
- 3D User Interfaces: Theory and Practice, 2nd Edition. Joseph J. LaViola Jr., Ernst Kruijff, Ryan P. McMahan, Doug A. Bowman, Ivan Poupyrev. Addison-Wesley, 2017. ISBN-13: 978-0134034324.
- Selected readings from websites and the ACM or IEEE Digital Library
- Virtual/augmented reality hardware for project (e.g., your own, or via loan from course instructor or Carleton School of Information Technology)

Course Organization:
The course consists of lectures and seminars, and a term-long major research project. Students will also meet the instructor for individual project guidance. Graded items are detailed below.

Course Grading:

Item	Weight %
Term Research Project	**55**
Seminar Participation	**15**
Seminar Discussion Leads (3)	**15**
Late-Term Exam	**15**
TOTAL	**100%**

Term Research Project Components

Item	Weight %
#1 Proposal	**7.5**
#2 Literature Review	**7.5**
#3 Methodology & Ethics Protocol	**10**
#4 Presentation	**10**
#5 User Study & Final Report	**20**
TOTAL	**55%**

Late-Term Exam – 15%
There will be one exam, held during class time, near the end of the course. All topics in the course are eligible to appear, including content from lectures and seminar/discussions.

Research Project – 55%

The project (fully detailed in a separate document) involves conducting a term-long research project on a topic of current interest to the VR/AR/3DUI research communities. Topics are chosen in consultation with the instructor, and will be formally proposed in the first milestone. The project involves development of a specific VR system to address the research questions detailed in the project proposal, and informed by the literature review (see below). The project must also include a user study – empirical evaluation of some aspect of how humans interact with VR technology via formal experimentation with human participants. Note for 2022: Given the challenges in conducting human participant research during the ongoing COVID-19 pandemic, participants will be limited to people you are already in regular contact with (e.g., members of your household, room-mates), remote deployment (e.g., via sending your application to people online, or equipment drop-off as necessary), or extended study on yourself (to be discussed further).

The project will culminate in a complete research paper, which will be presented in the final week of class. Projects are broken into the following parts:

- **Milestone #1 - Proposal**: The proposal involves a brief writeup of your research questions and goals of your project, identification of your chosen topic, effectively the introduction to your paper.
- **Milestone #2 - Literature Review**: Involves a review of (~12) academic research papers to inform/refine your choice of project, and summarize the current state of research in your chosen topic area.
- **Milestone #3 - Methodology & Ethic Protocol**: Draft of your experimental methodology. This includes details of participants, apparatus, procedure, and experiment design. This also requires a human participant research ethics application and Tri-Council Ethics Certificate (this is *required* before you can continue your project!!).
- **Optional - VR System Design/Development**: Development of software and hardware or identification and modification of existing software/hardware to use for your project. There is no "deadline", but it must be finished before you start the User Study (Milestone #5). Note that you may be able to avoid software development by using existing code. Some amount of technical tinkering is likely unavoidable (e.g., at minimum, getting VR hardware working). *Note: no grade item is associated with this.*
- **Milestone #4 - Presentation**: The final week is reserved for presentation sessions where you will conduct conference-style presentations of your project. Optionally, we may also set up a demonstration of your completed VR systems, so that other students and faculty can try out your VR system.
- **Milestone #5 - User Study & Final Report**: Conduct the user study detailed in your methodology writeup with several human participants who will use your VR system to accomplish a specified task. Analyze results, and document these as a "final report". This will include your previous proposal (now re-written as an "introduction" section), your literature review, and your methodology writeup.

Seminar Discussion Leads – 15%

Each student will lead the seminar discussion for **three separate seminars**. Discussion leads pick an assigned reading and present a short 5-10 minute summary, and come prepared with 3-4 discussion topics/questions to foster discussion amongst other students (~20-25 minutes). Grading is based on keeping discussion on-topic, bringing up insightful commentary on the assigned reading, and the quality of the discussion questions/topics prepared.

Seminar Participation – 15%

There will be 9 seminar discussions of assigned readings listed below. Students are expected to read **all** assigned readings for a given week (not just those you are discussion lead for), and be prepared to discuss them during

the seminar. Participation for each week is graded on a 3-point scale (0 = did not attend/participate; 1 = minimally prepared, did not answer questions/discuss material/comment on presentations; 2 = well prepared, answered questions/provided well thought-out comments, etc.). Participation is graded on 8 weeks, and is scaled to 15%.

Course Schedule/List of Topics by Week:

Week #	Week Date	Topic	Readings and Work Due
1	Jan. 11 Jan. 13	Course Introduction, Policies, Intro to 3D UIs History and Applications of VR	 3DUI: Ch1, Ch2
Seminar Readings (for Seminar 1 - Jan. 18): 1. Brooks, F. (1999). What's real about virtual reality? In *IEEE Computer Graphics and Applications*, 19(6), pp. 16-27. 2. Rizzo, A.S., Lange, B., Suma, E.A. and Bolas, M. (2011). Virtual reality and interactive digital game technology: new tools to address obesity and diabetes. *Journal of diabetes science and technology*, *5*(2), pp.256-264. **3.** Hoffman, H.G., Chambers, G.T., Meyer III, W.J., Arceneaux, L.L., Russell, W.J., Seibel, E.J., Richards, T.L., Sharar, S.R. and Patterson, D.R. (2011). Virtual reality as an adjunctive non-pharmacologic analgesic for acute burn pain during medical procedures. *Annals of Behavioral Medicine*, 41(2), pp.183-191.			
2	Jan. 18 Jan. 20	**Seminar 1**: Applications of VR Immersion, Presence, Embodiment	
Seminar Readings (for Seminar 2 - Jan. 25): 1. Bowman, D. A, McMahan, R. P. (2007).Virtual reality: How much immersion is enough?, *IEEE Computer*, 40 (7), 36-43. 2. Handali, J. P., Schneider, J., Gau, M., Holzwarth, V., & vom Brocke, J. (2021). Visual Complexity and Scene Recognition: How Low Can You Go? *IEEE Conference on Virtual Reality and 3D User Interfaces – VR 2021*, 286-295. 3. Argelaguet, F., Hoyet, L., Trico, M. and Lécuyer, A. (2016). The role of interaction in virtual embodiment: Effects of the virtual hand representation. *IEEE Conference on Virtual Reality - VR 2016,* pp. 3-10. 4. Slater, M. (2004). How colorful was your day? Why questionnaires cannot assess presence in virtual environments. *Presence*, 13(4), pp. 484-493.			
3	Jan. 25 Jan. 27	**Seminar 2**: Immersion, Presence, Embodiment 3D Display Technology	3DUI: Ch5 Bourke, P. (1999). Calculating stereo pairs.
Seminar Readings (for Seminar 3 - Feb. 1): 1. A. U. Batmaz, A. K. Mutasim, M. Malekmakan, E. Sadr and W. Stuerzlinger. (2020). Touch the Wall: Comparison of Virtual and Augmented Reality with Conventional 2D Screen Eye-Hand Coordination Training Systems. *IEEE Conference on Virtual Reality and 3D User Interfaces* – VR 2020, pp. 184-193. 2. Freitag, S., Weyers, B., & Kuhlen, T. W. (2016). Examining rotation gain in CAVE-like virtual environments. *IEEE Transactions on Visualization and Computer Graphics*, 22(4), 1462-1471. **3.** Kim, Hanseob, et al. (2020). Don't Bother Me: How to Handle Content-Irrelevant Objects in Handheld Augmented Reality. ACM Symposium on Virtual Reality Software and Technology - VRST 2020.			

4	Feb. 1 Feb. 3	**Seminar 3**: 3D Display Technology 3D Input Technology	*Project Milestone #1 due* 3DUI: Ch6

Seminar Readings (for Seminar 4 - Feb. 8):

1. Babic, T., Reiterer, H., & Haller, M. (2018). Pocket6: A 6DOF controller based on a simple smartphone application. In *ACM Symposium on Spatial User Interaction – SUI 2018*, pp. 2-10.
2. J. Auda, N. Verheyen, S. Mayer, and S. Schneegass. (2021). Flyables: Haptic Input Devices for Virtual Reality using Quadcopters. In *ACM Symposium on Virtual Reality Software and Technology - VRST '21*, pp. 1–11.
3. J. Hartmann, A. Gupta, and D. Vogel. (2020). Extend, Push, Pull: Smartphone Mediated Interaction in Spatial Augmented Reality via Intuitive Mode Switching. *ACM Symposium on Spatial User Interaction - SUI '20,* pp. 1–10.

5	Feb. 8 Feb. 10	**Seminar 4**: 3D Input Technology 3D Selection and Manipulation	 3DUI: Ch7

Seminar Readings (for Seminar 5 - Feb. 24):

1. Argelaguet, F., Andujar, C. (2013). A survey of 3D object selection techniques for virtual environments. *Computers & Graphics*, 37(3), pp. 121-136.
2. J. Ratcliffe, N. Ballou, and L. Tokarchuk. (2021). Actions, not gestures: contextualising embodied controller interactions in immersive virtual reality. In *ACM Symposium on Virtual Reality Software and Technology - VRST '21*, pp 1–11
3. Li, J., Cho, I., & Wartell, Z. (2018). Evaluation of Cursor Offset on 3D Selection in VR. In *Proceedings of the Symposium on Spatial User Interaction – SUI 2018*, pp. 120-129.

6	Feb. 15 Feb. 17	**Seminar 5**: 3D Selection and Manipulation Navigating Virtual Environments	3DUI: Ch 8 *Project Milestone #2 Due*

Seminar Readings (for Seminar 6 – March 1):

1. Ruddle, R. A., & Lessels, S. (2009). The benefits of using a walking interface to navigate virtual environments. In *ACM Transactions on Computer-Human Interaction – TOCHI*, 16(1), pp. 5-16.
2. Dong, T., Chen, X., Song, Y., Ying, W., & Fan, J. (2020). Dynamic artificial potential fields for multi-user redirected walking. In *IEEE Conference on Virtual Reality and 3D User Interfaces – VR 2020*, pp. 146-154.
3. Bozgeyikli, E., Raij, A., Katkoori, S. and Dubey, R. (2016). Point & teleport locomotion technique for virtual reality. In *ACM Symposium on Computer-Human Interaction in Play – CHI Play 2016,* pp. 205-216. *Note: ACM DL link accessible within Carleton or via VPN.*

Optional: Usoh, M., Arthur, K., Whitton, M., Bastos, R., Steed, A., Slater, M., Brooks, F. (1999). Walking > walking-in-place > flying, in virtual environments. In the *ACM Conference on Computer Graphics and Interactive Techniques – SIGGRAPH '99,* pp. 359-364. (**Note**: cannot be used for seminar leading)

READING WEEK – FEB 21 – 25 – No Class

7	March 1 March 3	**Seminar 6**: Navigating Virtual Environments Empirical Evaluation & Experimental Design	3DUI – Ch. 11 MacKenzie, I. S. (2013). Chapter 5: Designing HCI Experiments. In *Human-Computer Interaction: An Empirical Research Perspective*

No seminar next week! Instead, in addition to the regular lecture, you will meet in your project group with the instructor for detailed one on one feedback on your project (the project workshop) and to help guide your user study proposal (due the following week). Schedule TBD.

8	March 8 March 10	Project Workshop 3D User Interfaces	 3DUI: Ch 9

Seminar Readings (for Seminar 7 - March 17):

1. Simeone, A.L., (2016). Indirect touch manipulation for interaction with stereoscopic displays. *IEEE Symposium on 3D User Interfaces – 3DUI 2016*, pp. 13-22.
2. Kyian, S., & Teather, R. J. (2021). Selection Performance Using a Smartphone in VR with Redirected Input. In *ACM Symposium on Spatial User Interaction – SUI 2021,* pp. 1-12.
3. Jiang, Haiyan, and Dongdong Weng. HiPad: Text entry for Head-Mounted Displays Using Circular Touchpad. *IEEE Conference on Virtual Reality and 3D User Interfaces – IEEE VR 2020,* pp. 692-703.

9	March 15 March 17	**Seminar 7**: 3D User Interfaces Cybersickness	*Project Milestone #3 Due*

Seminar Readings (for Seminar 8 - March 24):

1. Caserman, P., Garcia-Agundez, A., Zerban, A. G., & Göbel, S. (2021). Cybersickness in current-generation virtual reality head-mounted displays: systematic review and outlook. Virtual Reality, 1-18.
2. Venkatakrishnan, R., Venkatakrishnan, R., Bhargava, A., Lucaites, K., Solini, H., Volonte, M., Robb, A., Babu, S., Lin W.C., and Lin, Y. X. (2020). Comparative Evaluation of the Effects of Motion Control on Cybersickness in Immersive Virtual Environments. *IEEE Conference on Virtual Reality and 3D User Interfaces – IEEE VR 2020*, pp. 672-681.
3. Farmani, Y., Teather, R.J. (2020). Evaluating discrete viewpoint control to reduce cybersickness in virtual reality. *Virtual Reality* (24), pp. 645–664.

10	March 22 March 24	**Seminar 8**: Cybersickness Project Workshop	

No seminar next week! In addition to the usual lecture, you will meet in your project group with the instructor for one on one project feedback. Schedule TBD. You should have a working prototype of your test system and user study should be operational. Run the instructor through a short version of your proposed user study.

11	March 29 March 31	Late Term Exam Perceptual Illusions, Grand Challenges & Wrap Up	 *3DUI Ch. 12*
Seminar Readings (for Seminar 9 - April 7): 1. N. Nilsson, T. Peck, G. Bruder, E. Hodgson, S. Serafin, M. Whitton, F. Steinicke, E. S. Rosenberg. 15 years of research on redirected walking in immersive virtual environments. *IEEE Computer Graphics & Applications* 38 (2), 44-56. 2. Kohli, L., Whitton, M. C., & Brooks, F. P. (2012). Redirected touching: The effect of warping space on task performance. In the *IEEE Symposium on 3D User Interfaces - 3DUI 2012,* pp. 105-112. 3. Azmandian, M., Hancock, M., Benko, H., Ofek, E., & Wilson, A. D. (2016). Haptic retargeting: Dynamic repurposing of passive haptics for enhanced virtual reality experiences. In *the ACM Conference on Human Factors in Computing Systems - CHI 2016,* pp. 1968-1979. (Note: ACM DL link accessible within Carleton network or via VPN).			
12	April 5 April 7 April 12	**Seminar 9**: Perceptual Illusions Final Project Presentations Final Project Presentation (continued, if needed)	*Project Milestone #4 - Presentation* *Project Milestone #5 – Final Report*
Seminar Readings:		**N/A – *No readings or discussion this week***	

While every attempt will be made to keep to the schedule listed above, circumstances may necessitate modifications throughout the semester.

Note: The links seen in the table above are provided to PDF versions of each paper/article. These are up-to-date as of Dec. 28, 2021, but may no longer be available by the time they are needed in the course. In *all* cases, these are archival papers that can be found in major online libraries and/or Google Scholar, even if the current PDF link is unavailable. Claiming you cannot find a given paper online will *not* be accepted as a reason to not have read it (i.e., grad students can be reasonably expected to be able to find these). If you are unable to find a given paper, please let me know in advance and I can help.

ACADEMIC ACCOMMODATION

You may need special arrangements to meet your academic obligations during the term. For an accommodation request, the processes are as follows:

Pregnancy obligation: Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, visit the Equity Services website **carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf**.

Religious obligation: Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, visit the Equity Services website **carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf**

Academic Accommodations for Students with Disabilities: If you have a documented disability requiring academic accommodations in this course, please contact the Paul Menton Centre for Students with Disabilities (PMC) at 613-520-6608 or pmc@carleton.ca for a formal evaluation or contact your PMC coordinator to send your instructor your Letter of Accommodation at the beginning of the term. You must also contact the PMC no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable).

After requesting accommodation from PMC, meet with your instructor as soon as possible to ensure accommodation arrangements are made. For more details, visit the Paul Menton website **carleton.ca/pmc**.

Survivors of Sexual Violence: As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit **carleton.ca/sexual-violence-support**.

Accommodation for Student Activities: Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, visit **https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf**

ACADEMIC INTEGRITY: The University Senate defines plagiarism in the regulations on instructional offenses as "to use and pass off as one's own idea or product work of another without expressly giving credit to another."

Borrowing someone else's answers, unauthorized possession of tests or answers to tests, or possession of material designed in answering exam questions, are also subject to university policy regarding instructional offences. Students who post their code online are making themselves a potential party to plagiarism and are subject to the consequences. For more information on Carleton University's Academic Integrity Policy, consult *https://carleton.ca/registrar/wp-content/uploads/Academic-Integrity-policy-June-2021.pdf*

COURSE COPYRIGHT: Student or professor materials created for this course (including presentations and posted notes, labs, case studies, assignments and exams) remain the intellectual property of the author(s). They are intended for personal use and may not be reproduced or redistributed without prior written consent of the author(s).

IMPORTANT DATES TO REMEMBER – Academic Year 2021-2022

WITHDRAWALS: The last day to withdraw from winter term courses with a full fee adjustment is **January 31, 2022**. Withdrawals after this date will create no financial change to winter term fees and will result in a permanent notation of WDN appearing on your official transcript.

The last day to withdraw from winter term courses is **April 12, 2022**.

OFFICIAL FINAL EXAMINATION PERIOD

Winter term: **April 14-28, 2022 –** Examinations are normally held all seven days of the week.

For a complete listing of academic and financial dates and deadlines for the 2021/2022 academic year, please visit https://carleton.ca/registrar/registration/dates/academic-dates/.