# Graphics & Interaction Group, The Computer Laboratory, University of Cambridge, UK

N. A. Dodgson, P. Robinson & A. F. Blackwell

neil.dodgson@cl.cam.ac.uk peter.robinson@cl.cam.ac.uk alan.blackwell@cl.cam.ac.uk
http://www.cl.cam.ac.uk/research/rainbow/

**Abstract**

*The Graphics & Interaction Group (the "Rainbow Group") at the University of Cambridge undertakes research in computer graphics, image processing, interaction devices, and interdisciplinary design.*

## 1. Introduction

The group has undertaken research in *computer graphics* since the 1960s. Over the decades the focus has moved from considerations of display hardware and hardware architecture (1970s), through rendering algorithms (1980s) and 3D display technologies (1990s), to our present work on modelling and imaging. Graphics research is primarily under the supervision of Neil Dodgson and Malcolm Sabin.

The group has undertaken research in *human-computer interaction* for many years. Much of that research has focused on novel interface techniques that put computing power into the hands of a wider range of users, under the direction of Peter Robinson. This work on interface techniques has been complemented by research into theoretical aspects of HCI, including cognitive science and design theory, under the direction of Alan Blackwell.

HCI research increasingly involves collaboration with other parts of the university. The Crucible network is jointly directed by Alan Blackwell, David Good (Psychology) and Nathan Crilly (Engineering Design Centre). Crucible has established around a hundred separate research projects.

The group was founded in the mid-1960s by Neil Wiseman. Cambridge had bought one of the world's first minicomputers, a DEC PDP-7, and its type 340 vector display. These proved a valuable tool for research on computer aided design, for mechanical components and electronic circuits. The *Rainbow* integrated CAD system combined electronic design, computer graphics, data structures and the control of change in large bodies of data, interests which have continued to challenge students in the group ever since.

© The Eurographics Association 2013.

## 2. Staff

Prof. Neil Dodgson works in graphics and imaging, Prof. Peter Robinson in interaction technologies, and Dr Alan Blackwell in interdisciplinary design. All three have PhDs from the University of Cambridge, Dodgson and Robinson in Computer Science, Blackwell in Psychology. Their earlier backgrounds are in Mathematics (Robinson), Engineering (Blackwell), Physics & Computer Science (Dodgson).

The group has 15 research students, working towards their PhD degrees, and four post-doctoral researchers, including Dr Malcolm Sabin who consults on subdivision and geometric computing . The wider department has 200 researchers (36 faculty, 40 post-doctoral researchers, and about 120 research students). There are 25 support staff, including electrical and electronic engineers.

**Figure 1:** *The group's laboratory space showing driving simulator, eye tracking, vicon motion tracking, with large tabletop display and human robot in the background.*

## 3. Facilities

The group is housed in the recently-built William Gates Building. Research students and post-docs are in two-person offices. The group has a large laboratory space (40 $m^2$) for interaction experiments and a small experimental suite with observation room for conducting human studies.

Amongst the equipment available to the group are a range of eye trackers (including a Tobii X120 and a Dikablis), a Lightspeed DepthQ stereoscopic projection system, a 10-camera Vicon 3D capture system, a 27-DoF Hanson Robotics HumanKind conversational robot, a six-projector tabletop display, a GamePOD GT2 driving simulator, a Mind Media NeXus-4 physiological monitor, a Baseline 7-piece hand evaluation set, and audio equipment comprising Genelec studio monitors, mixers, and recording microphones.

## 4. Collaborations

The group has funding from the UK Government (EPSRC), the European Union (EU FP7), and industry (Thales, Huawei, Kodak, Boeing, Google, Qualcomm). Dodgson has collaborated recently with MPII (Saarbrücken) and Microsoft Research (Cambridge), with PhD students taking internships at both organisations. Robinson has worked recently with MIT, University of Southern California, Thales, and Cambridge's own Engineering Design Centre. He organised the prestigious 2009 Royal Society meeting on Computation of Emotions in Man and Machines. Blackwell collaborates widely, through the Crucible Research Network, and through a range of other contacts in the design and art communities. Recent collaborations include those with anthropologists, psychiatrists, musicians, dancers, and sculptors.

## 5. Projects

**Subdivision surfaces** (Dodgson, Sabin, Kosinka, Shin, Shen) Continuing Cashman's work on reconciling standard subdivision with NURBS [CADS09].

**Stereoscopic displays** (Dodgson, Świrski) Investigating interaction on stereoscopic displays using pupil tracking.

**Aesthetic imaging** (Dodgson, Blackwell, Lieng, Tasse) Investigating ways to improve the tools and interface for artists, with a side-line in analysing modern art.

**Emotionally intelligent interfaces** (Robinson, Adams, Baltrušaitis, Banda, Davies, Imbrasaitė, Mahmoud) Inferring mental state from facial expression, voice, body language, and music. Applying these to interfaces.

**Personal projected displays** (Robinson, Davies) Exploring technologies to build large projected displays and using these to experiment with new user interfaces.

**Sketch-based interfaces** (Blackwell, Church, Stead, Tasse) Considering sketching as a programming modality and investigating wider issues across design domains.

**Inclusive user interfaces** (Blackwell, Robinson, Church, Bai, Stead) Considering ways in which user interfaces can be designed for end-user programming by non-experts or for use by people with disabilities.

## 6. Publications

The group publishes in a wide range of venues, as befits its wide range of interests. The most heavily used venues since 2009 are: *Affective Computing and Intelligent Interaction* (ACII, 10 papers), *Computer Aided Geometric Design* (6 papers), *Computational Æsthetics* (4 papers), and *Leonardo* (4 papers).

Amongst 140 papers published since 2009 are those at *SIGGRAPH* [CADS09], *CHI* [CMK*12, TR09], *CVPR* [BRM12], *ECCV* [ROD*10], *ETRA* [ŚBD12], and in *IEEE Transactions on Affective Computing* [PR11], *Pattern Analysis and Machine Intelligence* [SSR10], and *Broadcasting* [HDFP11]. Świrski and Richardt won the ACM student research competition at SIGGRAPH 2011 [ŚRD11]. Tuddenham was nominated for best paper at CHI 2009 [TR09].

## References

[BRM12] BALTRUŠAITIS T., ROBINSON P., MORENCY L.: 3D constrained local model for rigid and non-rigid facial tracking. In *Computer Vision and Pattern Recognition (CVPR)* (2012), IEEE, pp. 2610–2617.

[CADS09] CASHMAN T., AUGSDÖRFER U., DODGSON N., SABIN M.: NURBS with extraordinary points: high-degree, non-uniform, rational subdivision schemes. In *ACM Transactions on Graphics (Proc. SIGGRAPH)* (2009), vol. 28, ACM. article 46.

[CMK*12] COYLE D., MOORE J., KRISTENSSON P., FLETCHER P., BLACKWELL A.: I did that!: measuring users' experience of agency in their own actions. In *Proc. ACM Annual Conference on Human Factors in Computing Systems (CHI)* (2012), ACM, pp. 2025–2034.

[HDFP11] HOLLIMAN N., DODGSON N., FAVALORA G., POCKETT L.: Three-dimensional displays: a review and applications analysis. *IEEE Trans. Broadcasting 57*, 2 (2011), 362–371.

[PR11] PFISTER T., ROBINSON P.: Real-time recognition of affective states from nonverbal features of speech and its application for public speaking skill analysis. *IEEE Trans. Affective Computing 2*, 2 (2011), 66–78.

[ROD*10] RICHARDT C., ORR D., DAVIES I., CRIMINISI A., DODGSON N.: Real-time spatiotemporal stereo matching using the dual-cross-bilateral grid. *ECCV* (2010), 510–523.

[ŚBD12] ŚWIRSKI L., BULLING A., DODGSON N.: Robust real-time pupil tracking in highly off-axis images. In *Proc. Eye Tracking Research and Appl'ns (ETRA)* (2012), ACM, pp. 173–176.

[ŚRD11] ŚWIRSKI L., RICHARDT C., DODGSON N.: Layered photo pop-up. In *SIGGRAPH Posters* (2011), ACM. article 36.

[SSR10] SOBOL-SHIKLER T., ROBINSON P.: Classification of complex information: Inference of co-occurring affective states from their expressions in speech. *IEEE Trans. Pattern Analysis and Machine Intelligence 32*, 7 (2010), 1284–1297.

[TR09] TUDDENHAM P., ROBINSON P.: Territorial coordination and workspace awareness in remote tabletop collaboration. In *Proc. ACM Annual Conference on Human Factors in Computing Systems (CHI)* (2009), ACM, pp. 2139–2148.

© The Eurographics Association 2013.