Institution:
University of Cambridge
Unit of Assessment:
UoA9
Title of case study:
Dasher

1. Summary of the impact (indicative maximum 100 words)

In 1997 Professor David MacKay of the University of Cambridge Department of Physics developed Dasher, a software accessibility tool for entering **text** by zooming through letters displayed on a screen. Dasher has since transformed computing for tens of thousands of individuals unable to use a normal keyboard, and is recommended by many charities involved in assistive technologies, such as the European Platform for Rehabilitation network. Since 2008, Dasher has been downloaded over 75,000 times and has been ported to smart phones, making use of input devices such as tilt sensors and joysticks. Linking Dasher's information-efficient text generation from gestures or gaze direction to text-to-speech or real-time-text output channels has made Dasher an ideal component of augmentative and alternative communication (AAC) systems which address digital exclusion.

2. Underpinning research (indicative maximum 500 words)

During the second half of the 1990s the University of Cambridge Department of Physics' Inference Group, led by David MacKay (then University Lecturer, now Professor), conducted human-computer interface research to develop an information-efficient text-entry interface, driven by natural continuous pointing gestures. The first prototype of the resulting software, Dasher, was released in 1997.

In Dasher's zooming interface, the user writes by steering through a continuously-expanding two-dimensional world containing alternative continuations of the text, arranged alphabetically. Dasher was designed to use a language model to predict which letters might come next, and makes those letters easier to write by allocating more space on the screen to them. The language model can be trained on example documents in almost any language, and it adapts to the user's language as s/he writes. Part of the research of the Dasher project involved enhancing the language model, which is based on a text compression model called prediction by partial match.

The early development of Dasher was supported by partnership awards from IBM Zurich research laboratories, awarded in 1999 and 2001. The first research version of Dasher, released in 2002, could be driven by mouse or by gaze-tracker. The record-breaking performance of Dasher with a gaze-tracker was described in Nature in 2002 [Ref 2]. In 2002, the Gatsby Charitable Foundation's interest in the research underpinning Dasher led them to offer funding which continues to support a post of project manager/developer. This funding enabled significant research into producing enhancements to Dasher, including support for almost all languages, and the development of versions of Dasher driven by small numbers of buttons. MacKay also developed a "breath mouse" and demonstrated efficient communication by breath-Dasher.

Dasher has been ported to a wide variety of computer platforms including iPhone and Android (Dr Alan Lawrence, Research Associate 2009–2011) and interoperability with the evolving GNOME and Windows desktops is actively maintained (Patrick Welche, Research Associate 2008–present). Enhancements to support the disabled community include MacKay and Lawrence's 2009 development of one-switch Dasher for impaired users who can communicate with only a single switch, while Dr Emli-Mari Fanner (neé Nel, Research Associate 2009–2013) worked on the development of a gesture switch and head tracking algorithm (using images from a cheap web-cam) to interact with Dasher in 2010. Lawrence, Nel and Welche all worked with MacKay in the Inference Group. As is usual in open source software development of this type, many other developers volunteered their time privately, and most but not all were members of the Cavendish.

Collaborators who tested Dasher in the field include SU-DART (Swedish university hospital rehabilitation centre) and the Ace Centre in Oxford (which specialises in helping children with severe disabilities), and the Inference Group had a technical collaboration with IDRC OCAD Toronto who developed "Tecla" which allows one to control an Android mobile phone using a

wheelchair joystick, which the Inference Group interfaced with Dasher in one-button mode.

3. References to the research (indicative maximum of six references)

1. *Dasher – a Data Entry Interface using Continuous Gestures and Language Models – by David J Ward, Alan F Blackwell and David JC MacKay, UIST '00 Proceedings of the 13th annual ACM symposium on User interface software and technology, Pages 129 – 137, ACM New York, NY, USA 2000, ISBN:1-58113-212-3, DOI: 10.1145/354401.354427. Peer-reviewed proceedings.
2. *Fast Hands-free Writing by Gaze Direction – by David J Ward and David J C MacKay; Nature 22 August 2002 418, 838, DOI:10.1038/418838a. Peer-reviewed journal.
3. Fast and flexible selection with a single switch – by T Broderick, David J C MacKay in PLoS ONE 4 (10) 2009, e7481, DOI:10.1371/journal.pone.0007481. Peer-reviewed journal.
4. *Opengazer, Dasher and Nomon: Hands-free error tolerant communication – by Patrick R L Welche In: Proceedings of the 6th Cambridge Workshop on Universal Access and Assistive Technology (CWUAAT 2012), Cambridge, UK (CUED/C-EDC/TR158 ISSN 0963-5432). Peer-reviewed proceedings.
5. EU Deliverable D4.6.2b Alternate text entry system for mobile devices for users with motor disabilities – by Patrick R L Welche (2011).
6. EU Deliverable D2.5.2 Gesture switch, head pose estimation, head tracking and Ticker: from research to real-time – by Emli-Mari Nel (2011)

*References which best represent the quality of the underpinning research
In 2008, the EU Commission awarded MacKay 75% of 920,104 euros for 4 years' funding in the context of the ÆGIS project, an integrated project within the ICT programme of FP7, grant agreement 224348, to port Dasher to smart phones to create an AAC system, and to carry out research on very-low-cost gaze-tracking, the remaining 25% of the grant being provided by the Gatsby Charitable Foundation.

4. Details of the impact (indicative maximum 750 words)

Dasher is a fast and easy to learn text-entry interface using natural continuous pointing gestures, so taking advantage of humans' natural ability to make high-speed analogue movements. It can also use button presses, clicking and tapping gestures as input. As well as being faster, it is simpler to use than conventional writing systems and produces considerably fewer errors. In contrast to most writing systems, the Dasher approach enables efficient communication in almost all languages, regardless of alphabet. All that is required is an alphabet file that defines the alphabetical order, and a training text in the target language. Alphabet files have been created for 136 languages, and training texts have been produced in 20 European, 4 Asian, 15 Indian, 12 African, and 3 Middle-Eastern Languages. Special prototypes of Dasher were developed in 2011 for writing in Japanese and Chinese, making Dasher's transformational impact on users global.

Dasher is an open source product – the source code was released under the GNU public licence (GPL) in 2002 and all subsequent versions have been issued similarly. This guarantees free access to the Dasher source code, and allows it to be stored in the publicly accessible GNOME repository. Dasher was included in the GNOME 2 desktop in January 2004, and agreement was reached in November 2011 to include it in GNOME 3. The GNOME desktop is the default desktop environment for the Sun MicroSystems (now Oracle) Solaris operating system and most Linux distributions.

Since its release, Dasher has been downloaded from the Inference Group website over 120,000 times of which 71,000 times since 2008. It has also been included in software packages distributed by others, including Ubuntu, Solaris, and Tobii (who sell gaze-tracking systems).

Dasher was designed to use hardware that may be much smaller than conventional keyboards and is therefore particularly useful for smart phones and tablet computers. As a result of the Inference Group's continued research into porting Dasher to mobile devices [Ref 5], Dasher was made available for the Android market and the iPhone, iPod touch and iPad in 2010. It has been downloaded to Android devices over 5000 times with a user-review rating of 4.2/5 and from the Apple Store over 400 times since October 2012.

Dasher has transformed computing for those unable to use a conventional keyboard because it can be driven using any pointing device, such as a mouse, rollerball, touchpad, joystick or gaze-tracker. Since 2008, significant advances have been made in the usability of Dasher with pointing devices, particularly with gaze-trackers and joysticks. Dasher has proven to be ideally suited to be used with a gaze-tracker as it is mode free: you look at what you are writing, and do not need to escape into an error-correction mode, nor an "accept-model-predictions" mode as in systems which offer word-completions. Unlike other systems it is also robust to blinks and can infer and correct poor calibration. Dasher adapts to an individual's writing style to such an extent that it is sometimes possible to write several words using a single glance.

One issue which Dasher faced was that commercial gaze-trackers are expensive, and typically use special-purpose high resolution, high frame rate infra-red cameras. The significant cost of commercial gaze-trackers motivated research into gaze-tracking and head-tracking using ordinary cheap web-cams. So far, a gesture switch – an algorithm which learns and detects facial gestures such as "look up" or "smile" – and a head tracker suitable for hands-free writing with Dasher have been developed [Ref 6].

Dasher can also write text using discrete button presses as input, either by selecting a screen region, or using precise timing information. This feature prompted collaboration with IDRC (Toronto) who developed Tecla, a hardware device which converts wheelchair joystick controls into bluetooth keypresses with an on-screen keyboard to be able to use an Android smart phone using the joystick. As a result of the Inference Group's research [Ref 5], it is now possible to switch between the Tecla on-screen keyboard and Dasher so that writing a text message on a mobile phone using a single wheelchair button and Dasher in a new one-button mode became easy. Tecla was commercialised by Komodo OpenLab Inc. in 2012.

The Dasher development team receives positive feedback from users on a weekly basis confirming the transformative impact Dasher has made on their lifestyle quality and well-being. Examples of user testimony include:

"I am an occupational therapist in London who has been using Dasher for many years with children and adults with significant physical disabilities that prevent them from using a standard keyboard or mouse." (20 September 2012)

"I found your software on the web and think it is wonderful! My mother has ALS and although she can still use her hands typing is a one finger time consuming tiring effort, yet she has a lot to say. In addition she writes to many who live in Turkey in Turkish as she and her husband lived there for 25 years. Having that language available was a very happy surprise. I live in another state and your software will allow her to communicate with me and others via email and in the future using speech and eye gaze programs as needed. For that I say thank you." (18 September 2012)

"I have a personal example – an acquaintance of mine who had ALS. I installed Dasher on his computer, and in short order he was able to communicate with his wife and family much more rapidly, was able to compose documents and e-mails, etc. Made a very significant improvement in the quality of his life." (Accessibility Principal at Oracle – 5 April 2013).

5. Sources to corroborate the impact (indicative maximum of 10 references)

[1] Rerelease of Dasher on iPhone, iPod, iPad:
https://itunes.apple.com/en/app/dasher-text-entry/id568895508?mt=8

[2] Dasher on Android:
https://play.google.com/store/apps/details?id=dasher.android&hl=en

[3] Mobile Dasher review:
http://www.techsupportalert.com/best-free-onscreen-keyboard-osk.htm

[4] BBC Digital Planet 1 September 2009: Husband and wife team Kevin and Sarah Brown talk about their joint project to help stroke patients communicate more effectively using a simple tech solution:
http://www.bbc.co.uk/worldservice/science/2009/09/090901_digitalplanet_010909_1.shtml

[5] Dasher used with an Emotiv head set:
http://eightbar.co.uk/2012/06/08/even-more-mqtt-enabled-tvs/

[6] User testimony 1 on file

[7] User testimony 2 on file

[8] Accessibility Principal at Oracle statement on file