Institution:
Birmingham City University

Unit of Assessment:
Computer Science & Informatics (UOA 11)

Title of case study:
Vehicle Crash Test Analysis Systems

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

Based on research within the Digital Media Technology group, innovative multi-media technologies for capturing, structuring, and analysing real-time crash test data were developed, between 1996 and 2006, leading to transformational impacts on the professional practices of the global vehicle crash testing industry. Initially realised through an award-winning technology transfer programme with MIRA, the systems have been widely deployed by leading crash test organisations, supported faster vehicle design iterations and contributed to the design of safer vehicles. The underpinning research has directly contributed to the ISO standard (ISO/DTR 13499) and its current version. The impact is ongoing and long lasting since most systems in current use are largely based on the original technologies.

2. Underpinning research (indicative maximum 500 words)

Over the past two decades, research on novel techniques for developing real-time multimedia systems to support acquisition, analysis and exploitation of deeper knowledge has been gained through controlled scientific experiments, carried out by the Digital Media Technology research group, led by Professor **Athwal**. The research focused on developing time synchronisation models and effective means for capturing, analysing, and reasoning about information collected from concurrent multimedia data streams originating from multiple distributed sources. The group pioneered innovative technologies that effectively exploited the research results in the realisation of sophisticated multi-media systems in education, engineering, and manufacturing. The most significant and far reaching success has been demonstrated in the vehicle crash testing industry. The lasting technological innovations described in this impact case study are based on research contributions to the following complementary strands:

- Synchronisation of real-time multi-media data streams from multiple sources [R1]
- Correlation of video images with external real-time events [R1, R2]
- Development of methodologies for building multimedia systems [R3-R5]
- Design of effective human-computer interfaces to facilitate usability of systems with multimedia inputs from multiple sources. [R1, R3]
- Development of novel format, adopted by ISO international standard, for structuring and specifying multimedia data captured in vehicle crash testing to enable inter-operability. [R2, R3]

The design of synchronisation schemes for real-time data from multiple modalities, with a range of sample rates, enables the accurate correlation of data from multiple sources at any point in time. Typically such data involves photographs from still cameras at different angles, films from high-speed video cameras and numerical values from sensors placed at points of interests on objects such as vehicles and dummies. Specialised algorithms were carefully developed to allow efficient means of accessing, viewing, and analysing the time-synchronised streams and for accurately correlating an event with all relevant data in other streams at that instant.

The research has also made significant contributions to methodologies for the development of multi-media software systems by adopting an approach that emphasises the vital role of the user interface at the start of the software development lifecycle. The success of this approach was demonstrated through the incremental development of commercial multi-media systems for vehicle crash testing analysis such as (Motor Industry Research Association) MIRA's **DataViewer** and

Pixoft's **Vicasso**. Initially, a Rapid Disposable Prototyping approach was used to induce a constructive two-way interaction between the developers and users, typically, automotive engineers. This phase served to educate the engineers in the potentials of the multimedia technologies and to provide the developers with an initial requirements specification. The main focus was on addressing Human Computer Interaction (HCI) issues and ensuring that experimental interfaces, with minimal functionalities, are very intuitive to use. The next phase used an iterative Rapid Application Development approach to prototype several versions of the systems. The final phase relies on object oriented analysis and design techniques to implement the full system. Many of the features of this approach have subsequently been incorporated in current Agile Software Development Methodologies.

In terms of HCI the collaborative (co-creation) studies highlighted the importance of highly graphical user interfaces for fast intuitive access to data – with intensive use of vehicle and camera layout photographs and schematics, and concurrent viewing of multiple camera angles alongside graphs of transducer data. It was discovered that time synchronisation of video, transducer and simulation data was particularly powerful for the discovery of pertinent design weakness.

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

[R1] Athwal, C.S. and Robinson, J., "Synchronised Multimedia for Engineering and Scientific Analysis", Multimedia Systems Journal, 9, pp 365-377, Springer, 2003.

[R2] Robinson, J., Dallaway, M., Wellicome, P. and Athwal, C.S., "Crash Data Presentation Leveraging Existing Data Storage", *Society of Automotive Engineers*, Detroit, SAE 1998. doi:10.4271/980217.

[R3] Athwal, C.S., Robinson, J. and Cole, A., "The design and implementation of a multimedia system for the interactive and time synchronised analysis of vehicle crash tests", *European Conference Multimedia Applications, Services and Techniques — ECMAST '97*, Lecture Notes in Computer Science Volume 1242, Springer 1997, pp 79-94.

[R4] Smith, M. and Athwal, C.S., "A study of the use of cost effective multimedia in a manufacturing environment", *Advances in Manufacturing Technology*, *Proceedings of the 11th National Conference on Manufacturing Research*. Leicester, 12-15 September, 1995. Taylor & Francis, pp 749-753.

[R5] Athwal, C.S. and Cassidy, M., "A case study lead investigation into approaches towards the development of CAL materials using multimedia", *Proceedings of the International Conference Hypermedia*, Sheffield 1995. Sheffield Academic Press, pp 49-55.

Key Grants:

- 1996-99: Teaching Company Scheme programme 1601-MIRA/BCU funded by EPSRC. PI: **Cham Athwal**; Research Associates: Jimmy Robinson, Alan Cole, and William Drakeley. Value: £240K.
- 2000-03: FLEETS-Energy, PI: **Cham Athwal**, funded by EU grant. Value: £340K to lead the software development package out of £1.8M funding coordinated by MIRA.
- 2002-05: Two DTI SMART grants to work with Pixoft Ltd on further developments: WMR/31192/NS, 2002-03, £10K and SBS/01849/RD/1, 2004-05, £20K.

(Please note that University of Central England was renamed as Birmingham City University in 2008)

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

Crash tests are important part of the design lifecycle of new vehicles. Knowledge gained from analysis of crash tests data are vital for correlating design features with injury impacts to car users and pedestrians as well as for demonstrating compliance with standards and legal requirements. They involve huge amount of data, typically collected from about 200 channels, in a variety of formats including photographs and films from high speed cameras; numerical data from transducers such as accelerometers and load cells monitoring points of interests in vehicles and

dummies. They are expensive to conduct and, hence, the need for accuracy and efficiency in the processes used to gather, analyse and disseminate the information.

Prior to this innovative technology, a manually intensive paper and celluloid film based system was the norm in the crash test industry. This had several severe drawbacks, notably, authenticity of data, accuracy of correlations of images and relevant real-time events, speed of the analysis, ease of use and ability to disseminate.

The underpinning research has provided the enabling technologies for developing several multimedia systems that have revolutionised the professional practice in the global vehicle crash testing industry. The innovative technology was initially developed, between 1996 and 1999, through a TSB funded technology transfer programme with the Motor Industry Research Association (MIRA), the leading UK crash test company. The project was spectacularly successful and earned the Best TCS Programme Awarded among around 400 contestant programmes in December 1999 [T1]. The project resulted in MIRA's launch of two technologically advanced products: **DataBuilder**, for structuring and storing crash test data, and **DataViewer** for multimedia visualisation and analysis of the data. The systems became instantly market leading, had a transformational impact on the ***professional practices*** in the industry and were widely adopted by major national crash test facilities, such as MIRA and Millbrook [S1,S5], and international ones, such as General Motors and Ford.

The deployment of the multimedia systems enabled reduction in the analysis from weeks to a few hours. For the first time automotive engineers were able to analyse all of the results from a vehicle crash test on one platform in an integrated, highly intelligible system. The productivity of test engineers was dramatically improved empowering them to more effectively and speedily analyse and assimilate the data from each test, and draw conclusions for future design iterations [S1, S3, S5]. The research has directly contributed to a new ***international standard (ISO/DTR 13499)***. The format of data captured from crash tests were largely adopted from the research carried out in the group and published in [R3]. The contribution is still valid in the recently revised version of the ISO standard [S2].

Significant ***economic benefits*** to all the stakeholders can be claimed as a result of the dramatic improvement in the productivity of test engineers, speed of feedback to safety designers, and the optimisation of the processes underlying the whole lifecycle. In addition, the research has also resulted in a start-up company, Pixoft, led by Jimmy Robinson who was a Research Associate on the award winning TCS Technology Transfer project with MIRA. Robinson continues his cooperation with **Athwal**'s group to refine the system further, by supplementing it with additional functionalities and enhancing its analysis capabilities, into the new market-leading product called **Vicasso** launched in 2006 [S4]. Since 2008, this product is currently used by international car manufacturing companies such Jaguar Land Rover [S5], General Motors and Ford for crash test analysis as a well as by a variety of companies in contrasting domains such as Duracell, Unilever, NAC Image Technology, US Army and Dorel for wider scientific analysis of high speed phenomenon [S4].

Within this REF period, MIRA have used the systems for the analysis of rail safety, in particular studying the security of interior fittings such as seats in crash tests and for testing of aircraft seats. The systems have also been deployed to gather research-informed knowledge to support the design of "secure" **built environment**. Results from crash tests with roadside furniture and roadside restraints have influenced the design of large built environment national projects such as air terminals and government buildings [S1, S3].

Most pertinently knowledge gained through the routine use of these systems (and derivative systems from other suppliers) by the worldwide automotive industry has supported faster vehicle design iterations and has ultimately influenced the design of safer vehicles, indirectly benefiting the health of wider society. The design of safer cars has resulted in fewer fatalities and in less severe injuries to both car users and pedestrians [S3, S5].

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

Sources:

[S1] Statement from Senior Operation Manager at MIRA, testifying that Dataviewer software is still in current use for a wide variety of applications including crash testing, built environment security at Heathrow Terminal 5 and in Westminster. The research has also made substantial economic impact on MIRA by attracting new businesses and developing a high reputation of pioneering cutting-edge technologies for capturing and analysing crash testing data.

[S2] Statement from Software Development Manager at MIRA and a serving member of ISO standard committee on "testing vehicle safety" (ISO/DTR 13499) since 1997, confirming that the result of **Athwa**l's research has been incorporated in the initial ISO standard for crash test data and is present in later updates and current version.

[S3] Statement from Senior Consultant at MIRA, indicating that the design of safer cars has resulted in fewer fatalities and in less severe injuries for both car users and pedestrians. Research that revolutionised the technologies for crash testing has influenced the designing safer vehicles.

[S4] Statement from Research Associate on the TCS project (1996-1999) and director of Pixoft Diagnostic Imaging Ltd (2000-current), the start-up company, confirming that **Vicasso** software, currently used by his company and clients, is founded on the research carried out by **Athwa**l's group 1997- 2006. Since 2008, Vicasso software has been used by many companies, predominantly those who use High Speed cameras for photo-instrumentation tasks. A large portion of these customers are in the automotive industry and include Jaguar Land Rover, Tata, Ford Motor Company, MIRA Ltd, Millbrook Proving Ground, Unwin Safety Systems, and Dorel.

[S5] Statement from Senior Manager for Vehicle Safety at Jaguar Land Rover since 2011 and previously Manager of Crash worthiness at Millbrook Proving Grounds, confirming that the software has been in use while he was at Millbrook as well as by Jaguar Land Rover for a number of years. The innovative systems have contributed to designing better safety in vehicles and have made indirect impacts on saving lives and lessening injury impacts caused during vehicle crashes.

Testimonials:

[T1] Certificate of Teaching Company Scheme Best Technology Transfer Programme award in December 1999.