

| |
|--|
| <p>Institution: University of Cambridge</p> |
| <p>Unit of Assessment: UoA15</p> |
| <p>Title of case study: Computer Vision in Virtual Retailing</p> |
| <p>1. Summary of the impact (indicative maximum 100 words) Research at the University of Cambridge Department of Engineering (DoEng) since 1997 created methods for reconstructing a three-dimensional (3D) model of an object from a single two-dimensional photograph. Metail, a company founded in 2008, sponsored further research at the DoEng and commercialised the results in an online fashion retailing application. Metail enables customers to select an item of clothing and see how they would look wearing it from a variety of angles, having entered just one photograph of themselves and a few basic body measurements. Metail attracted over GBP3.5M investment. Its application is used by Shop Direct, Tesco, Warehouse, Zalando and Dafiti. Sales data shows that the Metail application increases the propensity of customers to buy and reduces the proportion of goods returned.</p> |
| <p>2. Underpinning research (indicative maximum 500 words) Professor Roberto Cipolla (appointed as a Lecturer in the DoEng in 1992 and promoted to Professor in 2000) has led research in the DoEng on computer vision with the aim of reconstructing 3D models of objects from 2D photographs.</p> <p>Initially, Cipolla simplified the research aim in two ways: (1) choosing buildings as the objects, because they are generally rectilinear and their parallel edges determine vanishing points; (2) working with the outline of objects in multiple photographs to reduce the ambiguity created by using just one photograph.</p> <p>Grants from the EPSRC and Office Workstation Limited (subsequently Panasonic) supported research from 1996 to 2002. By studying the geometry of perspective and vanishing points to recover camera pose, Cipolla's team devised efficient algorithms and methods to enable reconstruction of architectural scenes (Ref 1). Extension to multiple viewpoints enabled the team to produce Photobuilder in 1999, which was a PC-based application that could generate 3D models of buildings in standard Virtual Reality Modelling Language (VRML) from images of an architectural scene (Ref 2). Assumptions about buildings generally having parallel sides and orthogonal walls reduced ambiguity. Triangulation of features and texture mapping was used to create the detailed and fully rendered 3D VRML models.</p> <p>Cipolla's next step was to attempt to model more complex 3D objects in the Digital Pygmalion Project that was funded by Toyota from 2003 to 2006. Cipolla and his team discovered how to identify automatically key features on an arbitrary object and its precise silhouettes from a series of uncalibrated photographs. They used this information to determine the precise viewpoint in every photograph. The accurate viewpoint information combined with the silhouettes combined with detailed texture information enabled generation of an accurate 3D mesh even when the object was very complex and lacked clear surface features. The final overlay of texture on the 3D mesh completed reconstruction of the object (Ref 3).</p> <p>Cipolla then led the research to model complex 3D objects once more, but with just a single uncalibrated image rather than many and one broad class of complex object, the human body, rather than any object. This research ran from 2008 and 2011 commissioned and supported by Metail. The research addressed three challenges:</p> <ol style="list-style-type: none"> 1. Cipolla and the team needed to obtain body shape measurements from a single photograph of the customer, but knew that the photograph required some simple reference geometry; otherwise there would be too many variables. They asked customers to take photographs of themselves standing in a doorway, which provided a simple rectilinear reference. This gave just enough information for their system to calibrate the camera, derive the viewpoint and calculate measurements of the customer's shape. This research built on the approach created for |

Impact case study (REF3b)

Photobuilder.

2. It is impossible to compute accurately the 3D shape of a human body from measurements taken from one photograph without information that categorises the range of likely shapes; there is too much ambiguity. Cipolla and his team devised a method for defining any human body shape with a vector of morphing parameters using an existing database of 2000 3D models of real human bodies as training data.
3. The team then created a method to find the most likely vector of morphing parameters given a set of measurements by learning a Gaussian Process Latent Variable Model. Adding customer-input body measurements, such as height and weight, to those that could be computed from the photograph reduced ambiguity. The morphing parameters were then used to generate the most likely 3D shape of the customer.

The work was published in a series of papers (Refs 4, 5 and 6).

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

1. R. Cipolla, T. Drummond and D. P. Robertson: "Camera Calibration from Vanishing Points in Images of Architectural Scenes". In Proc. British Machine Vision Conference, Nottingham, UK (September), Vol 2, pp.382-391, DOI: 10.5244/C.13.38, 1999.
2. *D. P. Robertson, R. Cipolla: "Building Architectural Models from Many Views Using Map Constraints". ECCV 2002, LNCS 2351, pp.155-169, DOI: 10.1007/3-540-47967-8_11, 2002.
3. *C. Hernández, G Vogiatzis and R. Cipolla: "Multiview Photometric Stereo". IEEE Trans. Pattern Analysis and Machine Intelligence (PAMI), Vol 30 (3), pp.548-554, DOI: 10.1109/TPAMI.2007.70820, March 2008.
4. Y. Chen and R. Cipolla: "Learning Shape Priors for Single View Reconstruction". In Proc. IEEE Int. Workshop on 3D Imaging and Modelling, Kyoto, Japan, October 2009, Gen paper, DOI: 10.1109/ICCVW.2009.5457443, 2009.
5. *Y. Chen and R. Cipolla: "Single and Sparse View 3D Reconstruction by Learning Shape Priors". Computer Vision and Image Understanding, Vol 115 (5), pp.586-602, DOI: 10.1016/j.cviu.2010.10.015, 2011.
6. Y. Chen, D. Robertson and R. Cipolla: "A Practical System for Modelling Body Shapes from Single View Measurements". In Proc. British Machine Vision Conference, Dundee (September), pp. 82.1-82.11, DOI: 10.5244/C.25.82, 2011.

*Research outputs that best represent the quality of the research

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

Metail was formed in 2008 with the aim of providing online fashion retailers with technology that would enable their customers to see on screen how they would look in new clothes before purchase, so that:

- customers would have more confidence when making an online purchase
- retailers would see increased sales because of this confidence
- retailers would receive fewer returned goods from dissatisfied customers.

Metail was founded by Tom Adeyoola (Ref 7) and Duncan Robertson (Ref 8). Adeyoola was a University of Cambridge graduate. Robertson was a postdoctoral researcher from Cipolla's team, who had partnered with Cipolla to commercialise research findings through their firm Redimension (founded in 2000). Cipolla had introduced Robertson to Adeyoola following a request for computer vision consulting services on an earlier project. Metail has 25 employees (July 2013) including Robertson, who became Metail's Chief Scientific Officer, and another member of Cipolla's research team.

Impact case study (REF3b)

Metail raised more than GBP3.5M in equity funding in six funding rounds, all from private individuals. Metail funded fundamental research at the DoEng with Cipolla's team to answer the technical challenge at the core of its business proposition: how to generate an accurate 3D model of a customer from a single photograph and a few simple measurements such as height and weight. This research is described in section 2. All intellectual property arising from this research was assigned to Metail, which filed patent applications.

The first version of the Metail application was launched in 2011 via Facebook. Metail has completed live trials, in which real customers make real purchases, with five retail businesses in the UK, Europe and South America. Three of these businesses have signed full contracts and discussions are underway with the other two. By the end of July 2013, over 300,000 people have created 3D body models, called MeModels, using Metail.

Details of the use of Metail by five retail businesses are subject to strict confidentiality, but the following information has been released:

- **Tesco** agreed to trial Metail on its Facebook online retailing page in 2012. Emily Shamma, Director of Tesco Clothing Online, said: *"We know the main reason people get nervous about buying clothes online is simply because they cannot try them on first. Although there has been talk about 'virtual fitting rooms' before, until now the technology has not been able to combine styling, accurate fit and size based on peoples' specific measurements. If our customers tell us they like this, we could see real business benefits, not only with more people opting to shop online for clothing, but also helping to reduce returns, commonly caused by people ordering the wrong size"* (Ref 9). Tesco ran online tests with control and variant samples to measure the effect of Metail technology on the interest-to-sale conversion rate and the product return rate. The benefits of Metail were clear. In 2012, CEO and Senior Executives at Tesco gave it Tesco's Best Online Innovation Award (Ref 7). Tesco moved to contract with Metail and the strapline on Tesco's Virtual Fitting Room Facebook page became: *"We're delighted to let you know that the F&F Virtual Fitting Room has been so successful on Facebook that we have made it part of our main website!"* (Ref 10).
- **Warehouse** signed a long-term deal with Metail in January 2012 and has stated, *"We're hearing feedback from customers who are saying, 'I love this' and 'This is really exciting.' It's been really positive"* (Ref 11).
- **Shop Direct** publicly endorsed Metail at the Internet Retail Expo in Birmingham in 2013, when Paul Hornby, Head of eCommerce for Shop Direct, described the use of Metail in an experiment on the www.very.co.uk website at the end of 2012. The experiment was to measure the effect of Metail on sales of 150 product lines. Shop Direct's main objective was to reduce product return rates, but was pleased to see that it also increased sales conversion rates by 0.4%. Paul Hornby stated, *"It also reduced returns by half a percent. Now, half a percent doesn't sound massive in comparison to some of the numbers that you will hear, but we sell thousands and thousands and thousands of items every single day and if I can reduce returns on all of them by half a percent, I'm happy with that, so this, for us, was a big big deal"* (Ref 12). Shop Direct has contracted with Metail (Ref 7).
- **Zalando**, a Germany-based international retailer, has invested in testing Metail's virtual dressing room on its live site for an estimated 200 product lines from its own brands with the aim of reducing product returns (Ref 13).
- **Dafiti**, South America's fastest growing online fashion retailer, is trialling Metail (2013) with a view to adopting the technology (Ref 7).

In addition, the television broadcaster ITV has partnered with Metail to support the fashion segment, "Takeover the makeover", in its live programme, "This Morning", which is broadcast every weekday. The Metail system has featured on the programme since December 2012. A guest in the studio uses Metail to view clothing options and the audience can participate interactively at home by offering advice. The show has generated over 20,000 user outfit submissions per show

during the live hour and more than 10,000 'forwards' to the retailer's webpage per show (Ref 7 and 14).

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

The following people have given their permission to be named in the case study and may be contacted by reviewers to corroborate information about Metail:

7. Tom Adeyoola, Chief Executive Officer, Metail (business model, investment, sales) (permission given to name)
8. Duncan Robertson, Chief Scientific Officer, Metail (technology employed by the business) (permission given to name)

The following sources also corroborate the account:

9. "Tesco launches virtual 3D fitting room", Ed Owen, Marketing, 28 February 2012, <http://www.marketingmagazine.co.uk/article/1119577/tesco-launches-virtual-3d-fitting-room>
10. Tesco F&F Virtual Fitting Room page on Facebook (2013), www.facebook.com/Clothingattesco/app_261347243942251
11. "3-D Tech Lets Online Shoppers 'Try on' Clothes", Gwen Moran, Entrepreneur, 12 May 2013, www.entrepreneur.com/article/226091#ixzz2bTCfmKpP (originally published in the print edition as "A Perfect E-fit" in April 2013).
12. "Building trust", a presentation by Paul Hornby, Head of eCommerce, Shop Direct Group, given on 26 March 2013 at the Internet Retailing Expo in Birmingham, 26-27 March 2013, www.internetretailingexpo.com/the-eseller-theatre-conferences/
13. "Virtuelle Umkleidekabinen: Zalando testet Metail", CX-Commerce, 11 January 2013, <http://cx-commerce.de/2013/01/virtuelle-umkleidekabinen-zalando-testet-metail-korpervermessung-virtual-fitting-room-retouren/>
14. "Brilliant! Get me dressed, Metail" Teresa Novellino, Upstart Business Journal, 13 December 2012, <http://upstart.bizjournals.com/companies/rebel-brands/2012/12/13/fashion-fitting-startup-metail-gets-play.html?page=all>