**Research Assessment Exercise 2020**
**Impact Case Study**

**University:** City University of Hong Kong
**Unit of Assessment (UoA):** 14 - mechanical engineering, production engineering (incl. manufacturing & industrial engineering), textile technology and aerospace engineering
**Title of case study:** 3D Speckle Vision from Academic Research to the Real-World

## 1. Summary of Impact

The 3D Speckle Vision research carried out at CityU, which was related to a computerized 3D camera for real-time acquisition and processing of 3D object shapes, has been further developed byformer PhD students, which led to commercial products and a spin-off company (Orbbec Co. Ltd). Within 6 years, the company has become a leading provider of 3D sensing solutions for many high-tech applications. **The company presently has more than 300 employees, generates annual revenue of US$100 million and is valued at over US$1 billion**. It is based in Shenzhen and has research facilities in both China and USA.

## 2. Underpinning Research

The Croucher Laboratory for Optical Measurement and Nondestructive Testing at CityU was established by Prof Michael YY Hung, then Chair Professor and department head, with a Croucher Foundation grant. The laboratory is equipped with the state-of-the-art equipment and know-how to conduct applied research using various computer-aided optical techniques (holography, shearography, speckle vision, thermography, tomography, photoelasticity, moire methods and 3D computer vision). Numerous research projects were conducted in the laboratory and Prof Hung , Dr. Huang and Dr. Long Liu have published many significant papers in the field, such as [1,2,3,4,5].

Prof Hung was the PhD supervisor of Dr. Huang and Dr. Liu, who conducted doctoral research on optical methods, particularly 3D speckle vision. The use of laser-produced speckle pattern for 3D shape measurement was first conceived by Prof Hung and his students in their early work on specklegrammetry for precision surface coordinate measurement, herein referred to as "3D speckle vision." A speckle pattern is a random pattern produced by the interference of scattered laser light. The local speckle pattern around a point is uniquely defined like a finger print. 3D speckle vision is based on projecting a speckle pattern on a 3D surface. When projecting at an angle slightly offset to the camera direction, each speckle point will be laterally shifted according to the depth, and the shift magnitude is related to the depth of corresponding surface point. A digital speckle correlation algorithm is developed to accurately determine this shift and hence the depth.

## 3. References


1. **Y. H. Huang**, Farrokh Janabi-Sharifi, Y. S. Liu* and Y. Y. Hung, "Dynamic Phase Measurement in Shearography by Clustering Method and Fourier Filtering", *Optics Express*, Vol. **19** (2), pp606-615, Jan 2011.
2. **Y. H. Huang**, S. P. Ng**, L. Liu**, C. L. Li, Y. S. Chen and Y. Y. Hung, "NDT&E using

Shearography with Impulsive Thermal Stressing and Clustering Phase Extraction", *Optics and Lasers in Engineering*, Vol. **47** (7-8), pp774-781, JUL-AUG 2009.

3. **Y. H. Huang**, **L. Liu**, T. W. Yeung and Y. Y. Hung, "Real Time Monitoring of Clamping Force of a Bolted Joint by Use of Automatic Digital Image Correlation", *Optics and Laser Technology*, Vol. **41** (4), pp408-414, June 2009.

4. Y. Y. Hung, Y. S. Chen, S. P. Ng, **L. Liu**, **Y. H. Huang**, B. L. Luk, R. W. L. Ip, C. M. L. Wu and P. S. Chung, "Review and Comparison of Shearography and Active Thermography for Nondestructive Evaluation", *Materials Science & Engineering R-Reports*, Vol. **64** (5-6), pp73-112, May 2009.

5. **Y.H. Huang**, **L. Liu**, Y. Y. Hung and C.Y. Yiu, "In-Situ Shearographic Nondestructive Testing of Aging Concrete Structures", *Materials Evaluation*, Vol. **67** (4), pp437-443, APR 2009.

## 4. Details of Impact

The Department of Mechanical Engineering at CityU realized that today's engineering field is increasingly multi-disciplinary , and hence established the Croucher Laboratory for Optical Measurement and Nondestructive Testing to facilitate research and teaching in electro-optics and mechatronics. The department has an undergraduate program in mechatronics. Furthermore, the department emphasized on applied research relevant to the industrial needs. The efforts have produced significant impact. Much of the knowledge has been transferred to industry through department's graduates.

This study shows a very significant case that 2 PhD graduates carried their research from the Croucher Laboratory to industry. They formed Orbbec Company Ltd. in 2013 to further R&D and commercialize 3D speckle vision. The company produces a computerized 3D camera (integration of software and hardware based on 3D speckle vision) which has many real-world applications. **Within a short period of 6 years, the company has grown into a US$2 billion company with annual revenue of US$100 million**. The company is headquartered in Shenzhen with R&D facilities in Shanghai, Xian in China, and Seattle in USA. **It currently has more than 600 employees** and has been growing rapidly.

While many new applications are underway, major achievements today, as partnered with and supported by HP, OPPO and Ant Financial Group, include:

1. The development of a 3D imaging camera head for HP Sprout G2 for AR (augmented reality) applications.
2. The development of a 3D camera for cell phones
3. The development of the world's first Face ID for android phones
4. The development of applications for the financial sector.

Furthermore, the company is presently collaborating with many companies to develop applications in various areas including:

1. Retail. Through face recognition via 3D camera， every user can log into his/her own account, which is linked to a database that can provide companies with the data for the recommendation of suitable products.
2. Virtual fitting, smart Home, and smart city/security protection
3. Automotive.
4. 3D vision and Robot（Industry scanning and inspection)
5. Building scanning
6. Mobile phone
7. Logistics

With the advent of high sensitivity image sensors and fast computing hardware, Dr. Huang and Dr. Liu saw the opportunity and started up Orbbec Company to develop a 3D camera (an integrated software and hardware system) allowing 3D surface sensing to be performed in real- time. They have identified many potential applications and have been working with various industrial partners to develop the applications. The company is recognized by the Chinese Ministry of Science and Technology as a "unicorn" and has received the followings prestigious recognitions:

1. The award of 2014 Shenzhen "Peacock Project" for overseas high-level talent team.

2. The award of 2017 "Pearl River Talent Program" Team in Guangdong Province.

3. Selected in the 2017 list of unicorns released by the Torch Center of the Ministry of Science and Technology, China.

4. Astra S produced by Orbbec was named "the most advanced structured light 3D camera" by Springer Nature.

5. IFAA 3D Security Face ID Technology Pioneer Award，IFAA2018

6. Selected as "The King of the New Economy"in WISE 2018 New Business Conference.

7. Selected as "China's Star of Tomorrow" by Deloitte China

8. selected as "the world's 30 best AI startups"

9. Obtained the 21st Century Business Herald's "China's Intelligent Manufacturing Golden Great Wall Award

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

Orbbec Company, Ltd. (http://www.orbbec.com.cn/) has produced numerous intellectual properties. It has submitted 460 patents applications and so far 120 have been approved. Some selected patents include:

1. 一种手势识别方法与装置(Chinese Patent: CN104598915B)

2. 3D 图像装置、光辐射的保护装置及其方法(Chinese Patent: CN105097053B)

3. 一种实时生成目标深度信息的方法及其装置(Chinese Patent:CN103778643B )

4. 一种光学投影装置及深度相机 (Chinese Patent: CN106773489B)

5. 三维图像的获得方法、装置及系统(Chinese Patent: CN106254854B)

6. 多模式深度计算处理器以及 3D 图像设备(Chinese Patent: CN107105217B)

7. ASIC chip system dedicated for optical three-dimensional sensing(US Patent: US10013378B2)

8. Overall Z-direction displacement measuring system(US Patent: US10234264B2)

9. DEPTH CAMERA-BASED HUMAN-BODY MODEL ACQUISITION METHOD AND NETWORK VIRTUAL FITTING SYSTEM(US Patent: US10217293B2)

10. https://www.marketresearch.com/Market-Intelligence-Consulting-Institute-v3289/Development-Strategy-3D-Sensor-Unicorn-12566379/ [Description of Development Strategy of 3D Sensor Unicorn Orbbec]