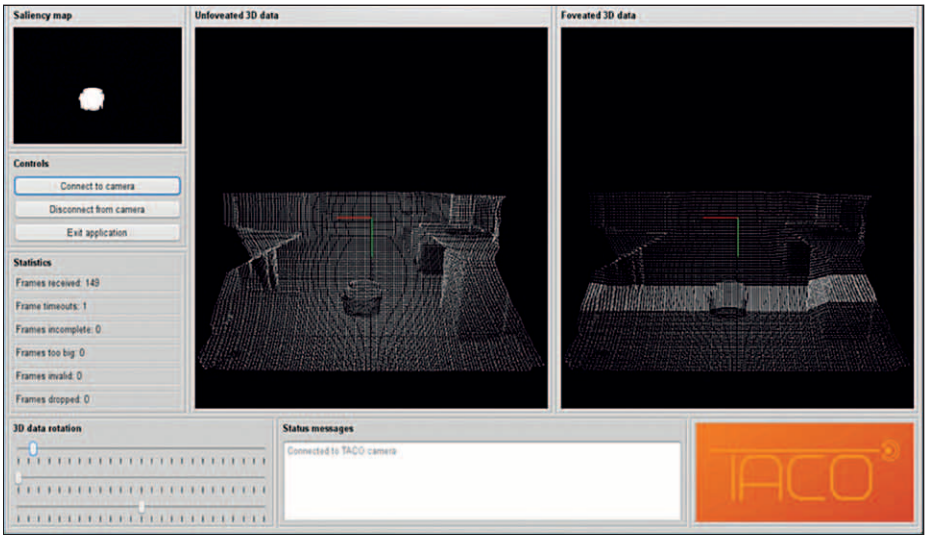
Newsletter
July 2011

Project Number: **248623** Project Website: **www.taco-project.eu** Project start: **February 1, 2010** Project duration: **3 years**

PHOTO: SINTEF



Screenshot showing the visualization of TACO data for the robot user. We can see how the detection of a moving object leads the TACO sensor to foveate on that object by sampling the interesting region denser than the background.

Tanja Scheliessnig, editor

PHOTO: Technikon

Editorial

Dear reader,

The TACO project finds itself in the middle of its second project year and it's time to reflect on the first valuable results of the project.
Our newsletter is intended to offer information on the interesting activities of the project, as well as to present new technologies created during the project.
In this first issue, the concept of foveation in the context of TACO, the TACO time of flight unit, as well as the importance of TACO for domestic service robot operations will be presented.
We hope the content of this issue is of interest to you. Any feedback is warmly welcome.

Foveation makes a difference

The TACO aims to develop a novel 3D sensor concept that addresses challenges within future robotics – their need to handle complex and unorganized scenes which requires a higher degree of autonomy.

The sensor concept is based on an innovative hardware solution combined with attention analysis in order to foveate in 3D. A system has foveation if it can acquire data with coarse resolution, apply fast object detection and then concentrate data acquisition in these regions-of-interest. The foveation concept is inspired by the human eye, which moves its sharp central vision region, fovea centralis, in saccadic motions towards objects it finds interesting. The sensor under development provides one million 3D data samples per second, which is not itself an impressive data rate compared to other 3D sensors. However, the sensor will be able to control where these measurements are done. This foveation capability makes it possible to increase both spatial and temporal resolution significantly in regions-of-interest by concentrating the data acquisition within these regions.
Detailed sensor control is possible due to a computer vision based foveation system. This foveation system software works as a feed-back loop for the sensor hardware and controls the data acquisition based on detected regions-of interest. Attention analysis of the scene is used to detect these regions, where the focus for attention can be e.g. motion, 3D edges or 2D edges.
The TACO project has implemented the software for the foveating 3D TACO sensor concept. We have demonstrated an algorithm for moving object detection, and apply this algorithm in a realtime sensor control loop, enabling foveation. The benefits of foveation we demonstrate through quantifiable metrics for region-of-interest detection and the successive enhanced sensor frame rate achieved with our foveation system, compared to a sensor without foveation. The foveation capability allows the frame rate to be increased by up to 8.2 compared to a non-foveating sensor, utilizing up to 99% of the potential frame rate increase. Since the sensor hardware is under construction, our current results are based on simulated hardware, while the foveation software is an actual real-time implementation.

Article Source: Trine Kirkhus, SINTEF

About TACO

TACO – Three-dimensional Adaptive Camera with object Detection and Foveation - is a specific targeted research project, co-financed by the European Commission under the EU Seventh Framework Programme. The project is running for 36 months from February 2010 to January 2013.
TACO aims at developing a 3D sensing system with real 3D foveation properties endowing service robots with a higher level of motion and affordance perception and interaction capabilities with respect to everyday objects and environments. The interdisciplinary project consortium consists of 7 European partners from industry and academia.

How TACO can make service robots smarter

To be safe and useful for their owners, domestic service robots must be able to perform a wide range of tasks: detecting and avoiding obstacles, self-localisation, finding and manipulating or transporting objects, and human-robot interaction.

For each of these points the robot's perception system needs to be supplied with appropriate sensor data. Depending on the task, the required measurement range, frame rate, resolution and field of view of the sensor data strongly varies.

Due to the lack of adaptability, no single commercial sensor currently available is sufficient, which makes using combinations of such sensors necessary. The TACO sensor has the potential to provide this hitherto missing adaptability by means of scene analysis and subsequent foveation. This analysis and associated segmentation of the scene are typical tasks of a robot's perception system. By making use of the sensor's processing results, the robot can dedicate more of its computational power to subsequent high-level tasks.

To demonstrate the advantages of this concept in the context of service robotics, the use case "Home Grasping" has been devised. A TACO sensor will be mounted onto a mobile robot that moves around in a home-like environment, and supply it with data required to perform the tasks mentioned in the beginning of this article. Furthermore, benchmarking the TACO sensor within the use case against state-of-the-art sensors typically used in service robotics will yield an objective comparison.

Article Source: Peter Einramhof, Technical University Vienna

TACO time-of-flight unit - 3D accuracy in the millimeter range

TACO combines for the first time an advanced micro-mirror concept with a laser scanning distance measurement to provide 3D imaging.

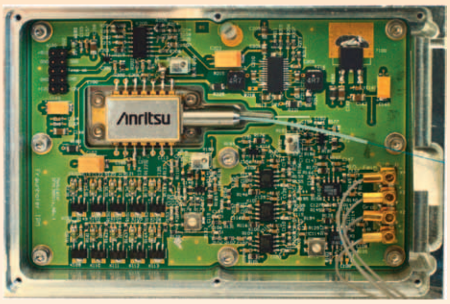


PHOTO: IPM

Printed circuit board predecessor of TACO's laser diode pulse generator

This approach provides both highly accurate data at unsurpassed point rate while offering large flexibility in the definition of image geometry, resolution and frame rate. However, the micro mirrors' flexibility for the image construction comes at the price of a technical challenge for the distance measurement: the small optically active area of the millimeter-sized mirrors must be compensated by the laser power and pulsed operating principle of the measurement circuitry. Moreover, meeting TACOs demands on the accuracy of the distance measurement translates into implementing a timing precision of only a few 10 picoseconds -- the round-trip time required by light to travel 1.5 mm.

TACOs measurement system uses a fiber laser generating 500 ps pulses at 1550 nm wavelength, triggered by the system's logic circuitry, permitting safe use of up to 1.5 kW laser pulse power while scanning. The divergence of the highly parallel laser beam is limited only by diffraction on the mirror surface to about 0.09° resulting in depth images that will show approx. 3 mm lateral resolution at 2 m distance.

The reception circuitry implements multiple parallel detection channels to maximize timing accuracy down to incident power levels below 1 µW, nine orders of magnitude (one billionth) below that of the emitted pulse. TACO will provide reliable imaging up to 7-8 m distance on dark (10% reflectivity) surfaces under substantial environmental lighting (30 % sun exposure). Using standard test equipment and a prototype implementation of the pulse generator, we have verified worst-case timing accuracy better than 20 ps (3 mm distance) for the input to the timing circuitry.

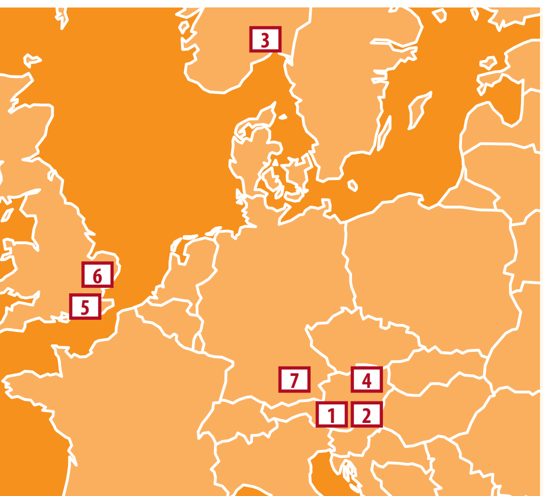
Article Source: Stefan Schwarzer, Fraunhofer IPM

UPCOMING EVENTS

INTERGEO - Conference and trade fair for geodesy, geoinformation and landmanagement
September 27-29, 2011
Nuremberg, Germany
www.intergeo.de

ICCV 2011 – 13th International Conference on Computer Vision
November 6-13, 2011, Barcelona, Spain
http://www.iccv2011.org

International THz Conference
November 24-25, 2011, Villach, Austria
http://www.thz-conference.com



Consortium:

1. **Technikon Forschungs- und Planungsgesellschaft mbH (Austria)**
2. **CTR AG, F&E Zentrum für Sensorik (Austria)**
3. **Stiftelsen SINTEF (Norway)**
4. **TU Wien (Austria)**
5. **Oxford Technologies (UK)**
6. **Shadow Robot Company (UK)**
7. **Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. (Germany)**

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SEVENTH FRAMEWORK PROGRAMME

TECHNIKON