TACO

Newsletter
August 2012

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PHOTO: TU Vienna

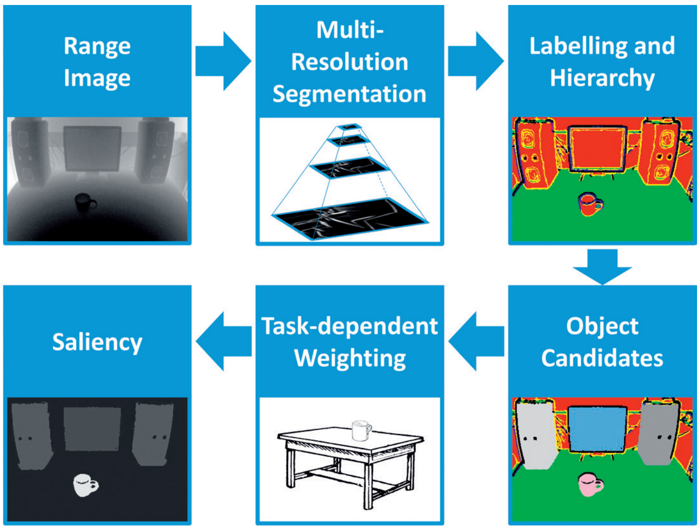


Figure 1: "Range images are segmented into edges and planar patches. The determination of support planes and subsequent extraction of object candidates is followed by assigning "saliency values" to the latter depending on how well they fit the target object description"

PHOTO: Technikon

Franziska Andratsch, editor

Editorial

Dear reader,

The previous and first issue of the TACO newsletter published in July 2011, already covered two interesting project topics: the foveating 3D TACO sensor concept and the TACO time-of flight unit as well. The current edition of our newsletter introduces to you now the range from image segmentation to object-based attention. Furthermore it features an article on synchronized micro scanning unit.
In addition the upcoming events are listed for you to have a view on the future conferences and fairs where the TACO project will be present.
I hope the content of this issue awakes your interest. We are in favor of any feedback, which is warmly welcome.

From Range Image Segmentation to object-based Attention

Domestic service robots must be able to safely navigate in cluttered and dynamic home environments. Furthermore, they need attention mechanisms to efficiently search for task-relevant objects to fetch and carry or to manipulate and operate them. With the TACO camera we aim at providing an appropriate tool.

Since service robots interact with a three-dimensional world, their perception systems require input data that encode structural information about the environment – typically range images like those provided by the TACO camera. For self localization often sufficiently large, planar vertical surfaces (e.g. walls) are extracted from the range image and compared against a map of the environment. A standard approach for determining obstacles in the robot's way is to find the ground plane within the range image, to remove it, and to consider the remaining data as obstacle points. Similarly, once the robot has found a possible object of interest, horizontal or vertical support planes such as table tops or doors are detected and removed. The remaining single-standing point clusters are examined in more detail (by means of foveation) to determine whether one of them represents the desired object such as a cup or a door knob.
To enable artificial cognitive systems like robots to quickly identify possible task-relevant regions or objects, visual attention systems have been proposed, e.g. the well-known bottom-up approach by Itti, Koch and Niebur (IEEE PAMI, 1998). These were designed to mimic the human vision and attention system by extracting and combining colour and edge features from conventional images, resulting in saliency maps to guide attention. Later extensions have been

PHOTO: TU Vienna

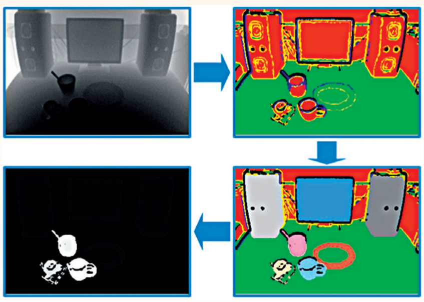


Figure 2: "A table scene as example for a horizontal support plane".

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 42 months from February 2010 to July 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.

added to work on range images or aiming at deploying attention at object level by estimating a "proto-object" region at the most salient location of the saliency map. Nevertheless, bottom-up approaches make it hard to produce meaningful saliency maps. Since the TACO camera uses saliency maps as basis for foveation, too, it would be counterproductive if they highlighted irrelevant regions of the range image for subsequent sampling at higher resolution.

In our approach, range images are segmented into features: planar surface patches, step edges, and convex and concave roof edges. Surface patches represent the boundaries of the environment, support planes and faces of objects, while edges indicate contours of and transitions between objects or parts thereof. Segmentation is done at multiple resolutions – coarse to fine – for selectable level of detail. The segmentation results serve as immediate input for navigation and are also used to establish a background-foreground hierarchy of support planes and object candidates. The latter possess attributes such as a 3D bounding box, pose within the scene and distance to the robot. Depending on how well their attributes fit those of the target object, the candidates receive a "saliency value" and are sorted in descending order. Finally, the object candidates with the highest saliency values are sequentially attended.

Two examples for robotic tasks are shown in the images below: grasping a cup on a table (top) and opening a door (bottom). Each example shows the range image, the labelled image as segmentation result, object candidates

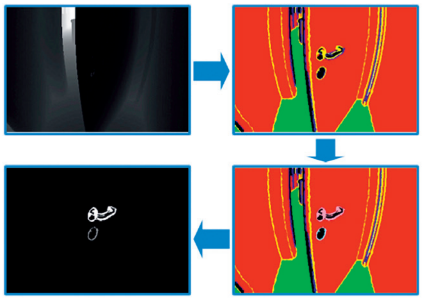


PHOTO: TU Vienna

Figure 3: "A door scene as example for a vertical support plane".

and saliency of these candidates based on the relevance for the task. The table scene is representative for objects on a horizontal support plane, and the door scene for an object on a vertical support plane.

Article Source: DI Peter Einrahmhof, DI Robert Schwarz, TU Vienna

Synchronized micro scanning Unit - Linearized Raster scanning enabling 3D-sensor with Adaptive resolution

2D MEMS scanning mirror with quasi-static resonant actuation enabling adaptive raster scanning of novel 3D TACO sensor

The novel 3D TOF laser camera with foveation properties is based on an advanced MEMS scanning mirror enabling adaptive laser scanning of the fast pulsed TOF distance measurement. The TACO concept of foveation - that is acquiring distance images with coarse spatial resolution, rapidly detecting regions of interest (ROI), and then concentrating further image acquisition on these ROIs with adaptive scanning to allow e.g. future autonomous robots to better interact with their surroundings – requires beside a fast pulsed TOF distance measurement unit a challenging 2D scanning device with adaptive and fast scanning, large effective aperture ≥ 5mm and > 60° FOV. The best technical compromise of the fast adaptive scanning unit were found in a synchronized

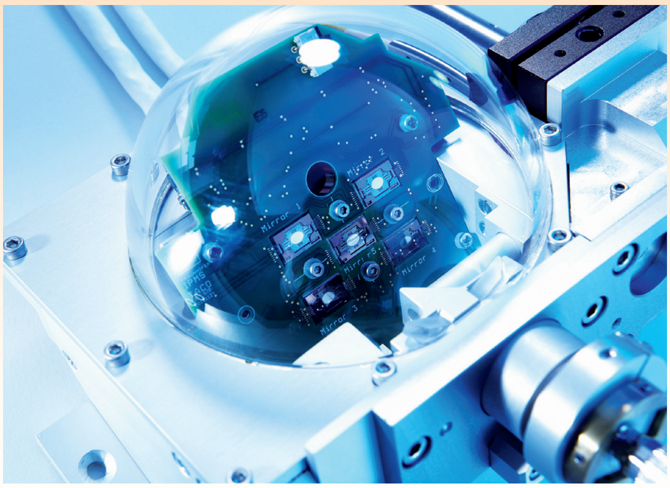


PHOTO: IPM / Kai-Uwe Wudtke

Figure 4: "Optical scan head with integrated MEMS scanning array"

driving of multiple raster scanning MEMS mirrors to meet opposite requirements of fast scanning (> 1000Hz), large optical scan range > 60° and large effective mirror aperture to provide sufficient reception. A novel gimbaled MEMS scanning mirrors were especially developed for adaptive raster scanning of the TACO 3D laser scanner. Large quasi-static deflections of ±10° are provided in vertical direction enabling also linearized scanning by driving control bellow its eigen frequency

PHOTO: IPMS

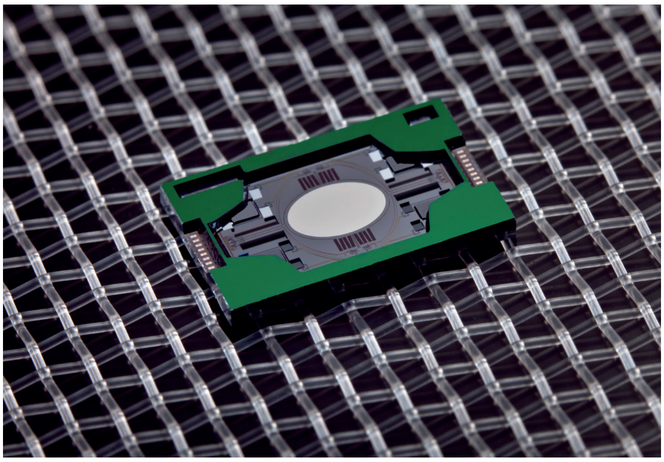


Figure 5: "TACO MEMS scanning mirror"

of 125Hz. The horizontal scan direction driven at resonance to guarantee fast bi-directional scanning at 3200 Hz of over a wide 80° optical scan range combined with high optical resolution diffraction limited by the 2.6x3.6mm elliptical mirror aperture to about 0.09° resulting in depth images of approx. 3 mm lateral resolution at 2 m distance. For real time position feedback piezo-resistive position sensors are integrated on chip for both scanning axis enabling closed loop control operation. To provide the full 5mm effective reception aperture of the TOF camera a synchronized driven MEMS scanner array - consisting of five hybrid assembled MEMS devices - are used. These five MEMS scanning devices are precisely assembled in a coaxial configuration around the sending mirror and combined with a prismatic detection optic to eliminate parasitic non-scanned light signals. All MEMS devices a synchronized operated in respect to the sending mirror to meet full reception aperture. The novel 3D TOF camera provides a distance measuring rate of 1MVoxel/s and an uncertainty of TOF distance measurement of 3mm at 7.5m measuring range enabling e.g. 3D images with 1Mpixel per second or 10 frames of 100Kpixel per second, respectively, over a 40°x60° (potentially 60°x80°) large FOV.

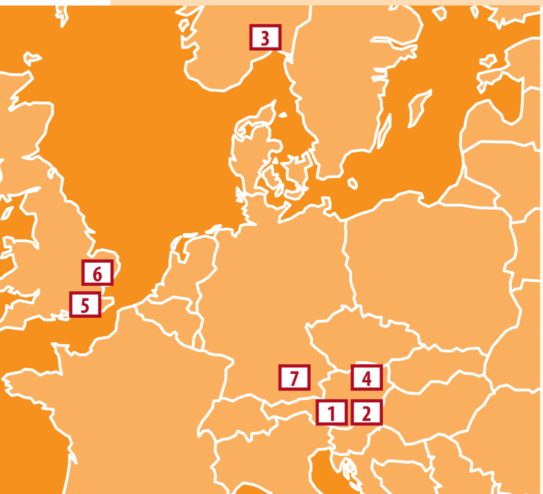
Article Source: Dr. Thilo Sandner, FHG-IPMS

UPCOMING EVENTS

Results of TACO will be presented by IPMS at the following fairs / trade shows where IPMS will be present with a booth:

- Security / Essen (D), September 2012: **www.security-messe.de**
- Vision 2012, Stuttgart, November 2012: **www.messeninfo.de/Vision-M617/Stuttgart.html**
- Photonics West 2013, San Francisco (CA), January 2013: **http://spie.org/x2584.xml**

SINTEF will be present at IROS 2012, 7-12 October. Vilamoura/Portugal with the paper "Fast High Resolution 3D Laser Scanning by Real-Time Object Tracking and Segmentation" **(www.iros2012.org/site)**



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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