Depth and motion cues with phosphene patterns for prosthetic vision

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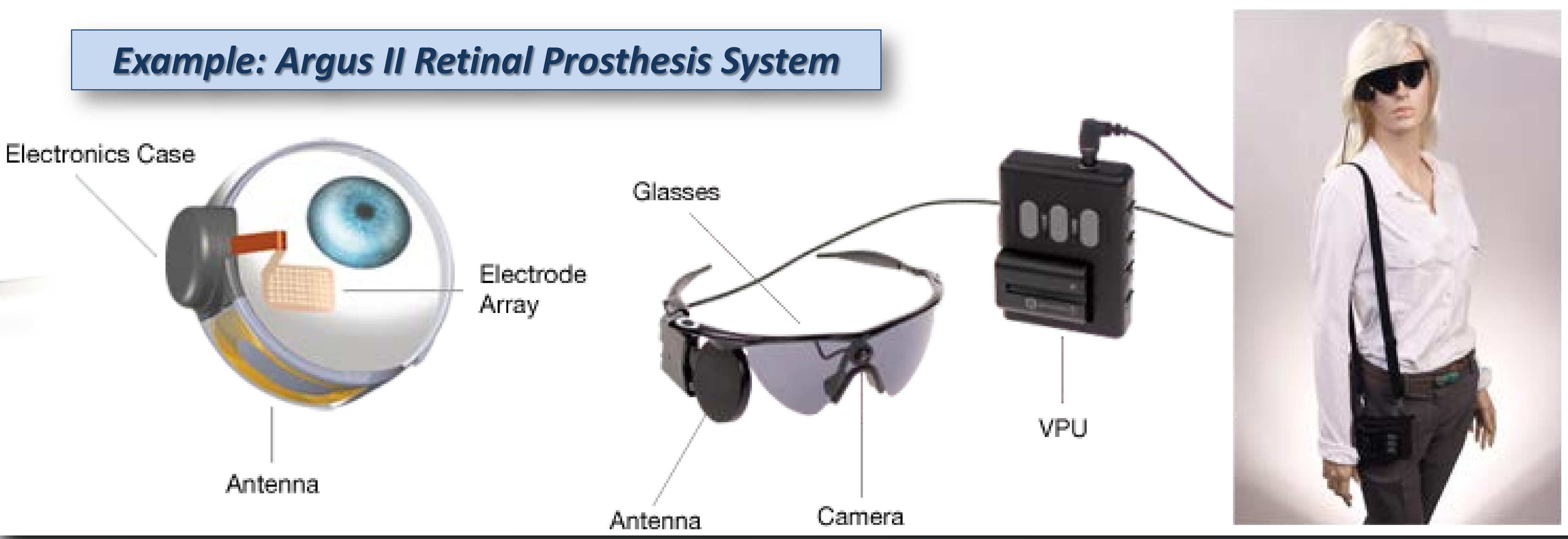
MOTIVATION: Prosthetic vision and how to transmit information from the environment

People affected by certain types of blindness can have some functional vision restored with **prosthetic vision**. Visual prostheses generally consist of retinal or cortical implants that via electrical stimulation generate a grid of **phosphenes**. The **perception** of the environment is typically solved with a **camera** mounted on the eyeglasses. The processed information is then transferred to the implant.

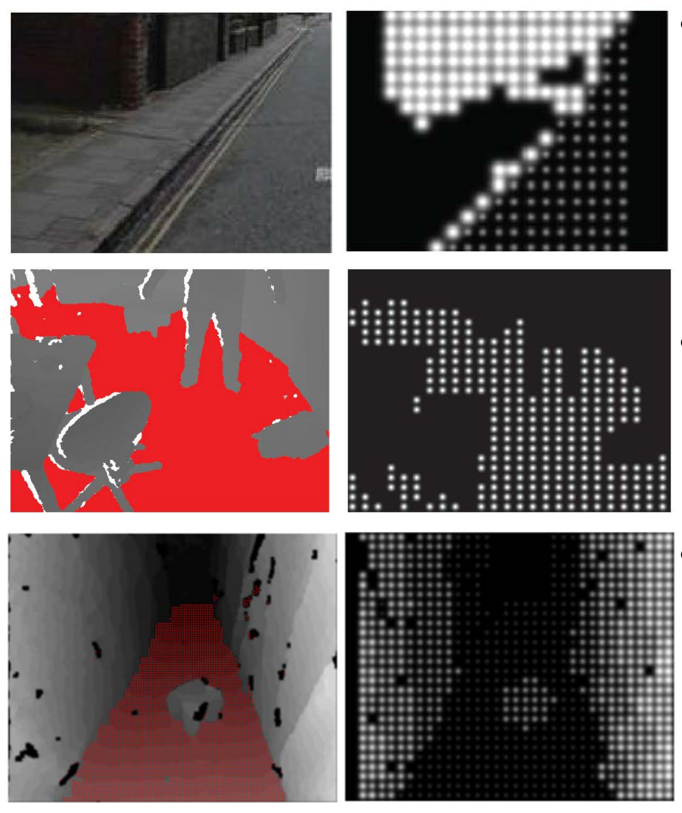
Example: Argus II Retinal Prosthesis System



The spatial and intensity resolution of the phosphene map is very limited due to **biological and technological constraints**. Thus, the problem of transmitting meaningful information remains an **open and challenging problem**.

Many methods have been proposed to extract and codify relevant features from the environment to phosphenic representation. However, **providing natural spatial and depth cues has not been successfully solved**.

Examples from the state of the art



- Semantic segmentation applied to curb detection [1]
- RGB-D ground detection [2]
- RGB-D ground and obstacle detection with augmented depth representation [3]

PROPOSAL: Provide depth and motion cues for safe and comfortable navigation with RGB-D perception

1. RGB-D based perception:

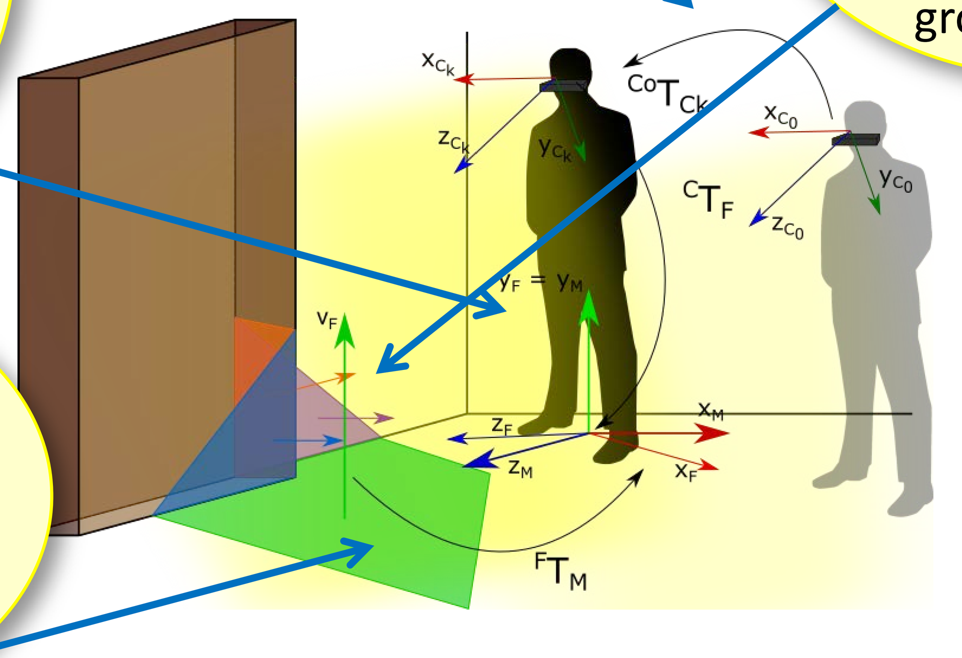
- **Ground** plane detection
- **Orientation** of the scene
- Visual **odometry**
- Detection of **obstacles**
- Estimation of **free space**

It is assumed a Manhattan World. The three main **directions** are obtained via RANSAC with the normals of the 3D points

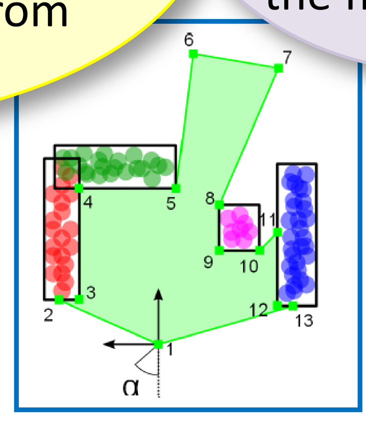
We estimate visual **odometry** with [4]

Obstacles are extracted from planar segmentation and clusterization after removing the ground points

The **ground** plane is recovered considering only the 3D points with vertical normals



The **free space** is the polygon on the floor plane whose edges are given by the bounding boxes of the obstacles and the rays from the camera

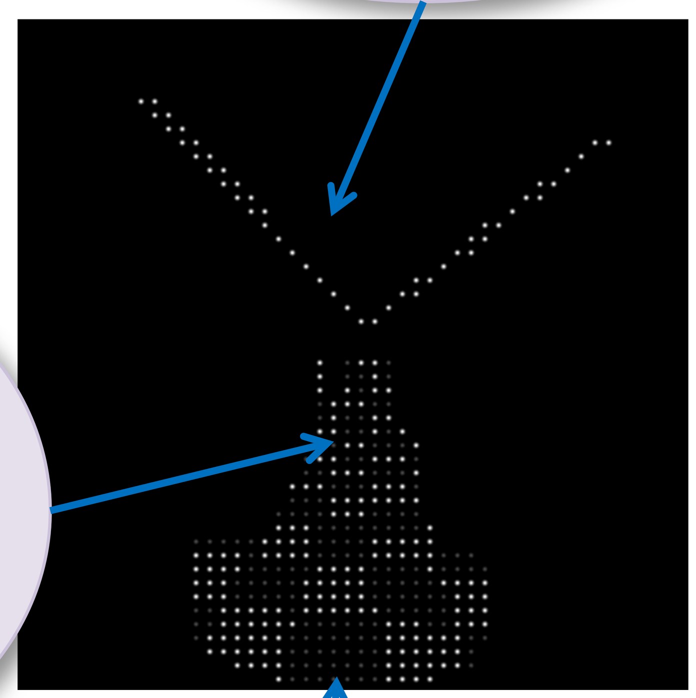


2. Iconic representation:

- Obstacle-free **walkable area**
- **Chess pattern** to provide sense of movement
- Upper part of the image suggests **direction** to follow

A **direction** may be suggested in the upper part, e.g. the vanishing point

Walkable area is drawn by computing intersections of the ray of each phosphene with the floor polygon

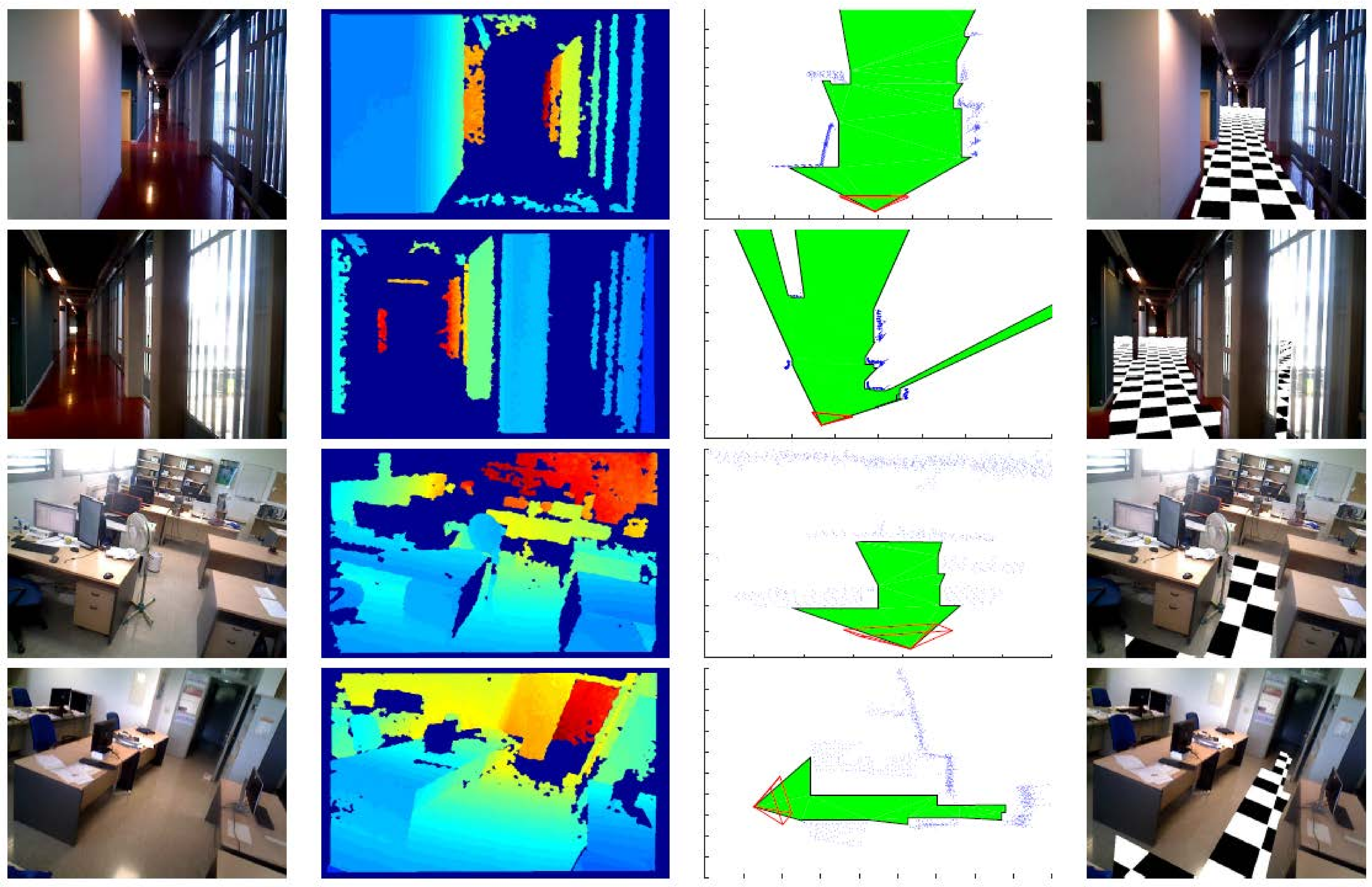


A **chess pattern** is drawn to provide depth and motion cues. It remains in absolute reference with the odometry

Videos!*

Evaluation of free space perception

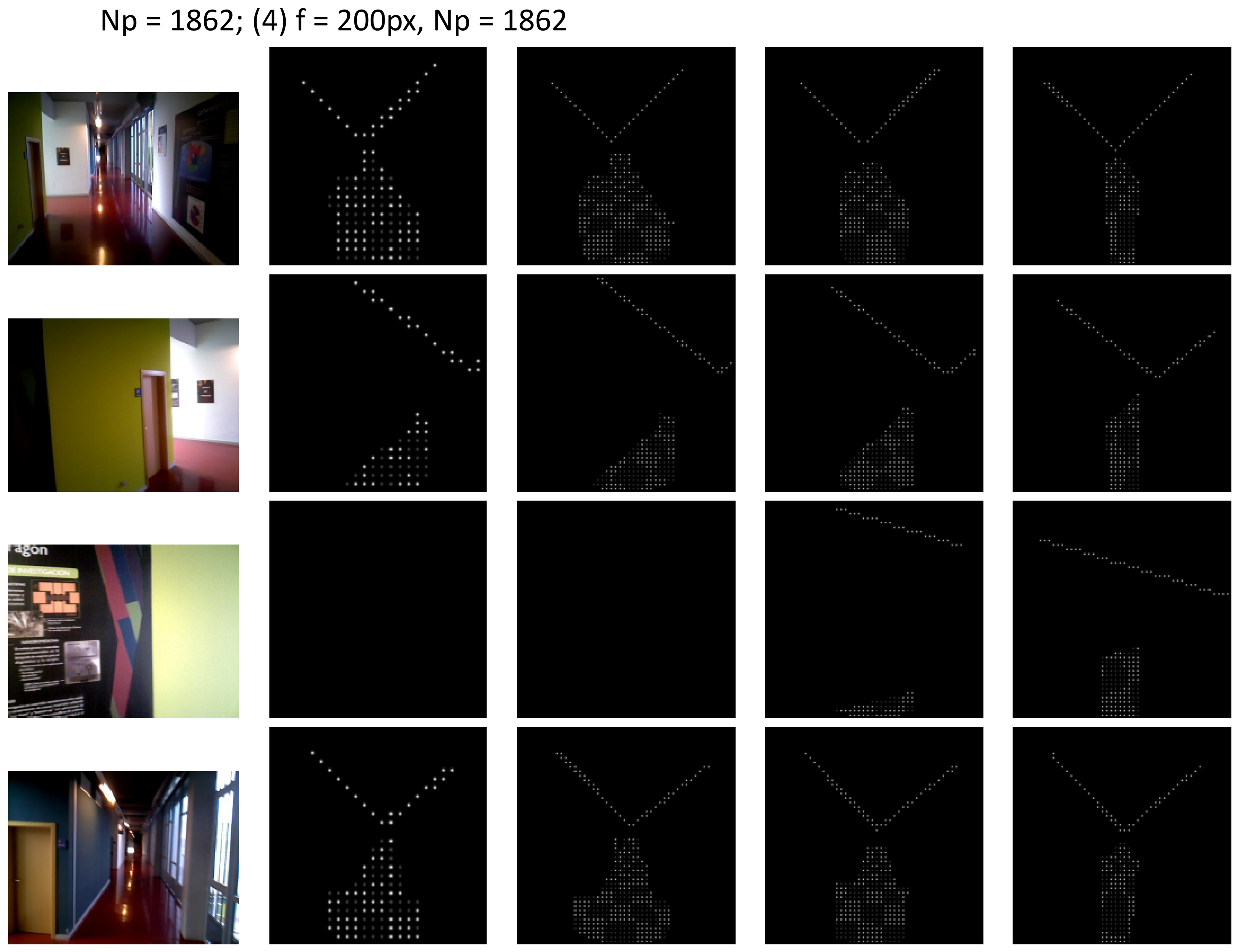
The system has been evaluated on **two environments** with real data: one from a corridor and another from an office. In the following figure we show four frames with the corresponding obstacle-free floor polygon.



RGB Image | Depth Image | Floor polygon | Chess pattern

Iconic representation of layouts

We have tested our iconic representation varying the **field of view** (with focal length, f) and **number of phosphenes** (Np). In the figure, the following parameters were used: (1) f = 525px, Np = 484; (2) f = 525px, Np = 1862; (3) f = 400px, Np = 1862; (4) f = 200px, Np = 1862



RGB Image (1) (2) (3) (4)

References

[1] L. Horne et al.: Semantic Labeling for Prosthetic Vision. Computer Vision and Image Understanding (2016)

[2] W. H. Li: Wearable Computer Vision Systems for a Cortical Visual Prosthesis. Workshop on Assistive Computer Vision and Robotics (2013)

[3] C. McCarthy et. al.: Mobility and low contrast trip hazard avoidance using augmented depth. Journal of Neural Engineering (2014)

[4] D. Gutierrez-Gomez et al.: Dense RGB-D visual odometry using inverse depth. Robotics and Autonomous Systems (2016)

*http://webdiis.unizar.es/~glopez/spv.html (Vídeos – permanent site)

Acknowledgments

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