BRNO UNIVERSITY OF TECHNOLOGY
FACULTY OF INFORMATION TECHNOLOGY

Graph@FIT
Faculty of Information Technology
Brno University of Technology
Božetěchova 2
Brno, 612 66
Czech Rep.

Simple Single-View Scene Calibration

Bronislav PŘIBYL and Pavel ZEMČÍK
{ipribyl, zemcik}@fit.vutbr.cz

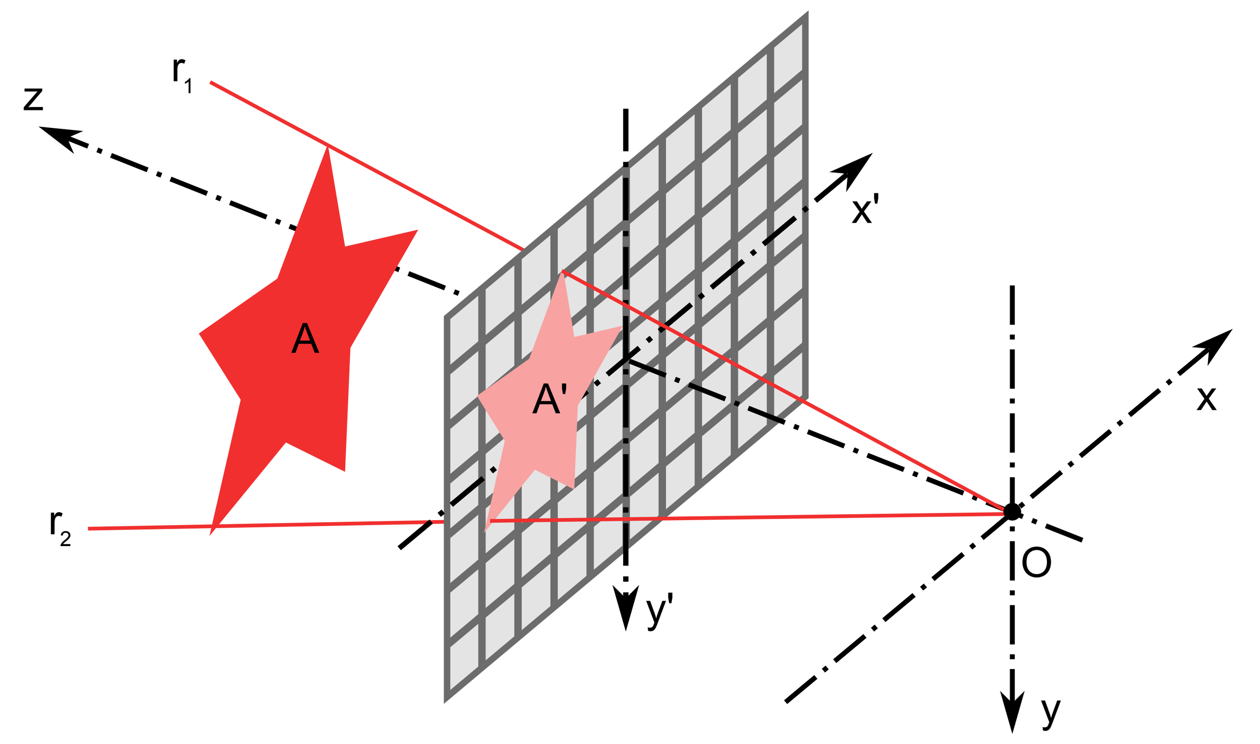
INTRODUCTION

Many computer vision applications benefit from calibrated scene which enables various measurements to be performed in the image. We developed a simple method of scene calibration without complex demands on the input data: No knowledge of internal or external camera parameters is required – just a single image of the scene with objects of known size present in it. The objects should also be positioned on a plane. It is irrelevant whether the objects are located automatically (e.g. via some object detector) or marked manually. We want to estimate parameters of the ground-plane and also real-world positions of the located objects. Consequently, measurements in the image can be performed, e.g. distances between the objects, sizes of some areas etc.

PROJECTION MODEL

We use a model of naturally occurring central projection.

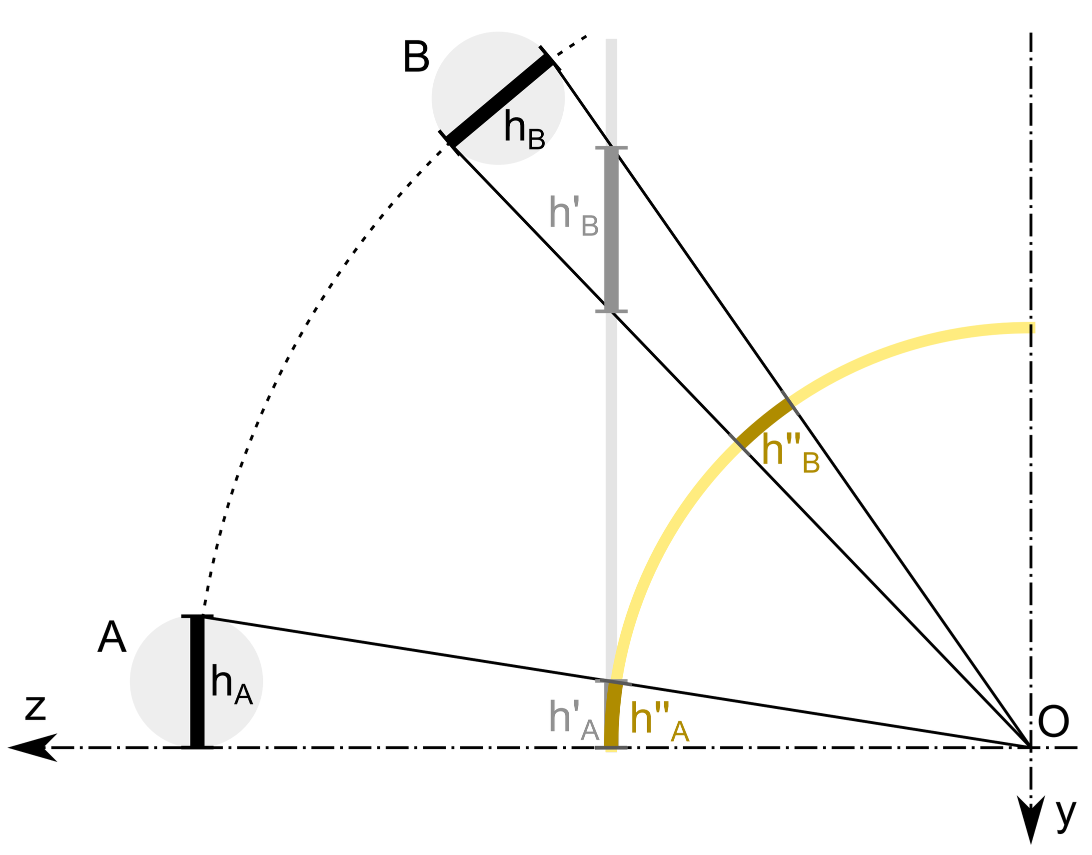
The screen is a planar lattice with:
– fixed aperture (can be chosen arbitrarily),
– variable position on the optical axis ("focal distance").



As the method should work with an arbitrary object detector, we have to introduce a generalization of object orientation – we assume all the located objects are oriented towards the camera. It is the identical case as if the bounding spheres of objects are detected.

Assumption:
All the located objects are oriented towards the camera.

When working with the scale of the map between the real object and its image, it is necessary to convert the size of the planar image to the size of the spherical image of the object. Otherwise the scale of the map of images further away from the optical axis will be distorted, as demonstrated on the figure below.



FINDING THE OPTIMAL SOLUTION

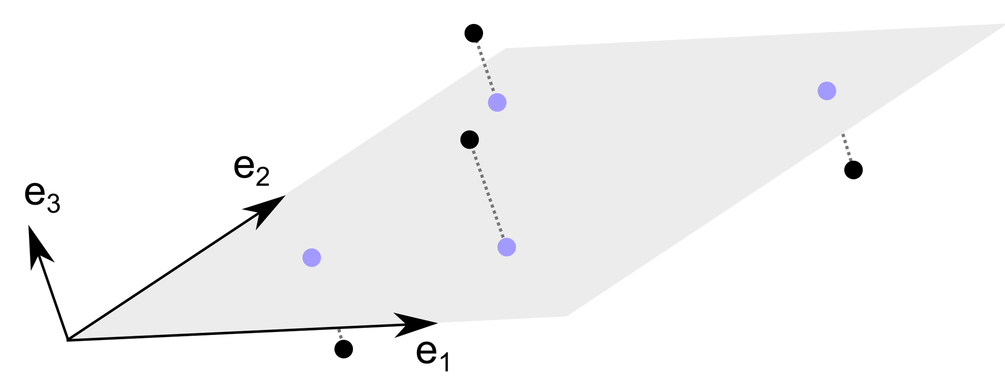
Assumption:
Objects of known size lie in a plane (e.g. rest on the ground).

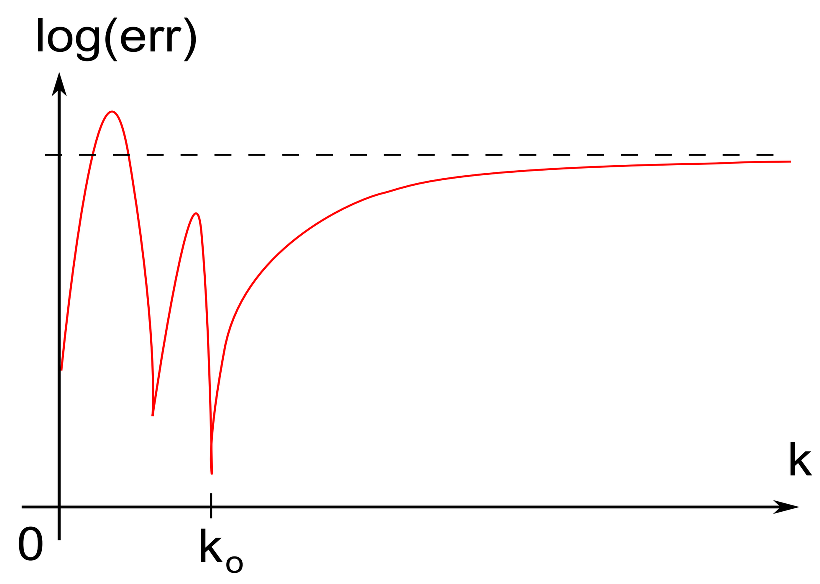
Task: Find the optimal parameters of backprojection of the image coordinates onto the objects real-world 3D coordinates, i.e. find the optimal "focal distance" of the screen when the scene has been captured.

Idea: Optimal parameters are found when backprojected points form a plane. Obviously, at least 4 points (objects) are needed.

Solution: Determine the parameters of the plane into which all the real-world points will be orthogonally projected by minimizing the mean squared distance from the points to their projections.

This can be achieved e.g. by using the Principal Component Analysis which gives directly two (eigen-) vectors defining the plane and the smallest eigenvalue which is equal to the mean squared error of the solution.

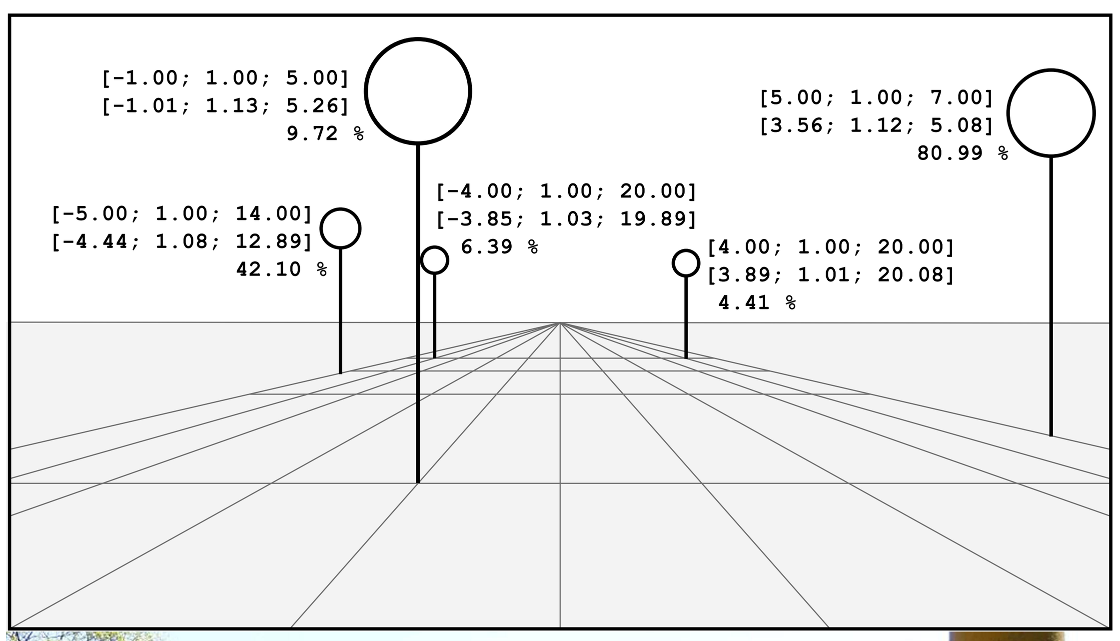


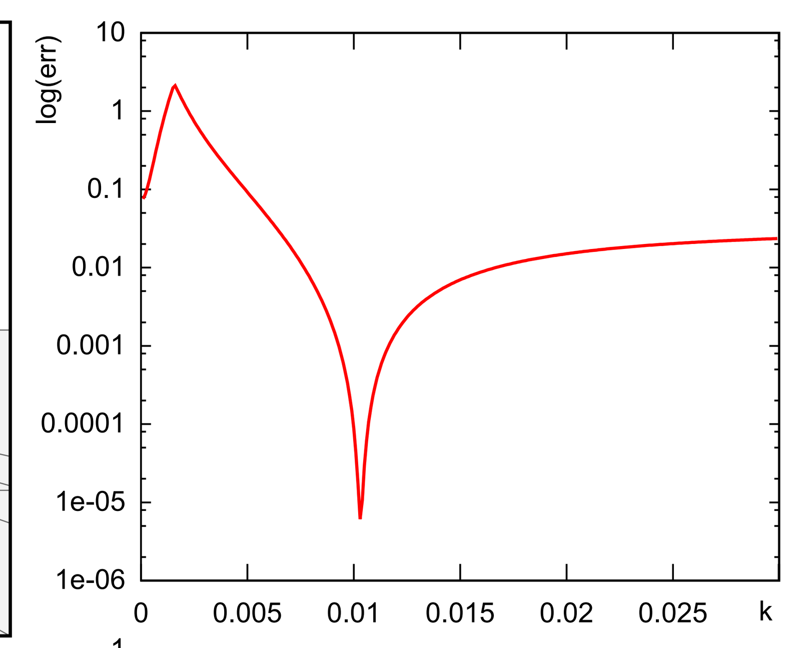


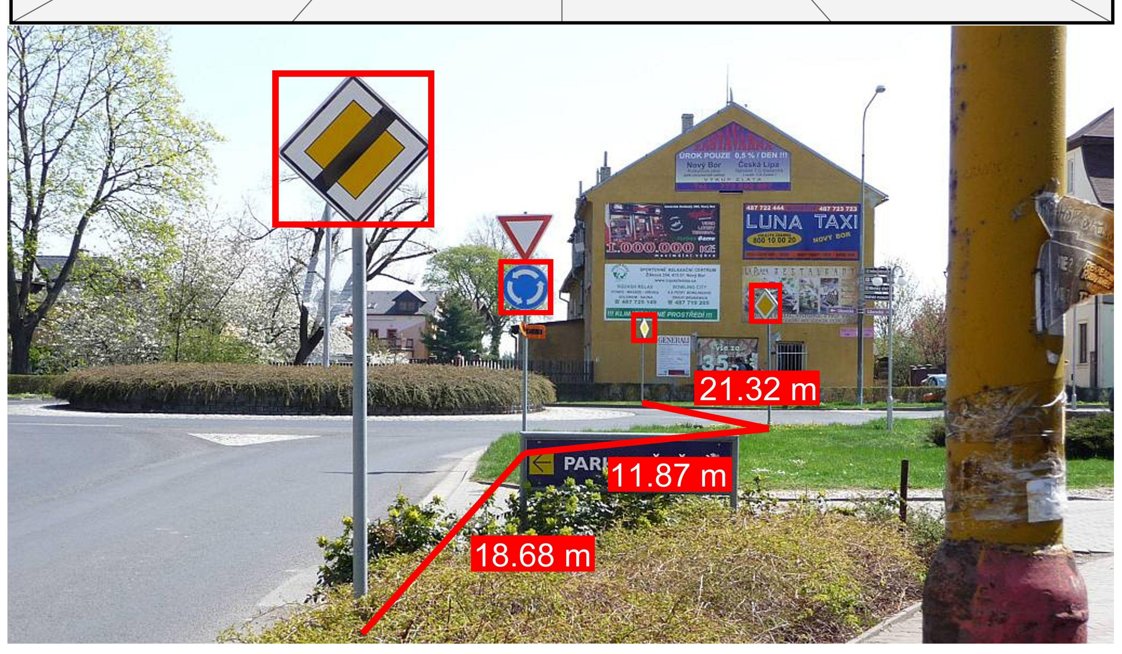
Because of non-linearity of the system, analytic calculation of eigenvalues is very complex. Therefore, we search for optimal projection parameter by searching for the minimum of an error function, which has a typical behaviour depicted on the figure above.

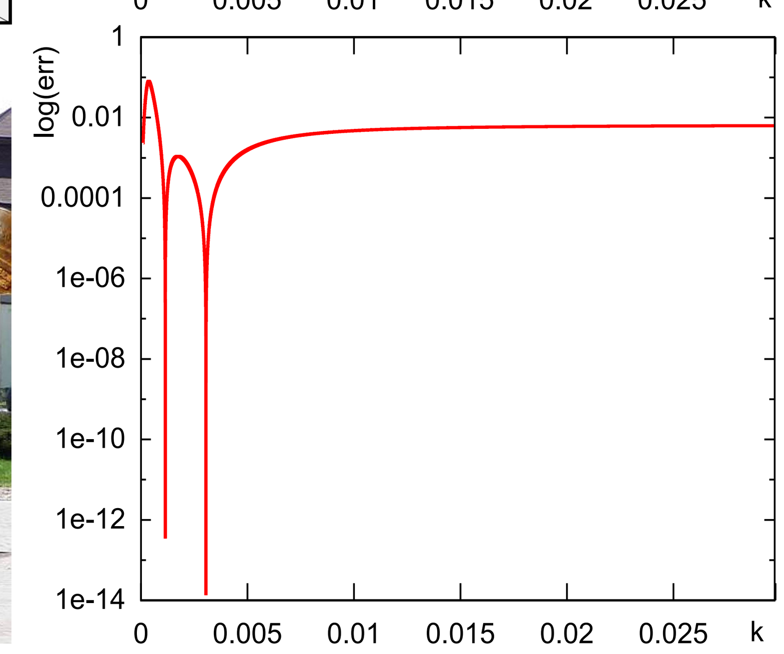
EXPERIMENTAL RESULTS

– Tested on a set of artificial as well as real scenes.
– Traffic signs were used for automatic object detection/localization.
– Every time the scene was planar, the solution has been found.









CONCLUSIONS

We developed a novel scene calibration method which exploits the spatial distribution of objects and relative sizes of their images.

+ Only 1 image needed, no knowledge of ext./int. camera parameters.
+ Fully automatic or semi-automatic operation.
– Planar scenes only.

Přibyl B. and Zemčík, P. 2011. Simple Single-View Scene Calibration.
In Proceedings of ACIVS 2011, Gent, Belgium.

This work was supported by the European Commission under the contract FP7-215453 and by the Ministry of Education Youth and Sports of the Czech Republic by projects MSMT 2B06052 and MSM 0021630528.