Stereo matching using convolution neural network and LIDAR support point grid

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INTRODUCTION

Depth estimation is used in such tasks as motion estimation and depth map calculation. It can be obtained by passive methods such as stereo matching. It usually begins with computation of matching cost of two pictures. Metric based on convolutional neural networks can improve the quality of disparity map [2].

Use of LIDAR data for support points grid calculation in stereo matching can reduce the error rate significantly.

Passive methods often show lack of quality in low-textured areas but produce dense disparity maps. Active methods such as LIDARs produce sparse maps but work better in low-textured areas. A combination of these methods can increase the quality of output disparity map.

OBJECTIVES

The following objectives were solved in the presented work.

- **Implementation of a stereo matching method that uses LIDAR data as support points.**
- **Support points grid parameters adjustment.**
- **Proposed stereo matching method evaluation.**

METHOD

The idea is to use data obtained from LIDAR as support points grid. This means that the support points disparities are not calculated now but taken directly from the LIDAR disparity map. In this paper we do not consider the data fusion task itself in details. As LIDAR data for tests we use ground truth data from Middlebury. We also use a CNN for matching cost computation. Figure 1 shows the scheme of the proposed method.

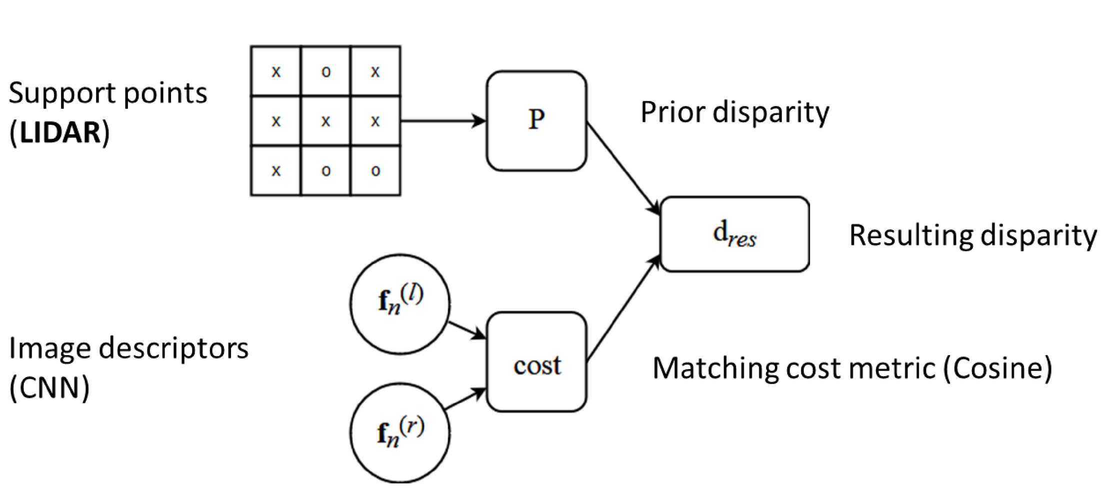

Fig. 1 Scheme of the proposed method

Figure 2 shows the data flow of the proposed method.

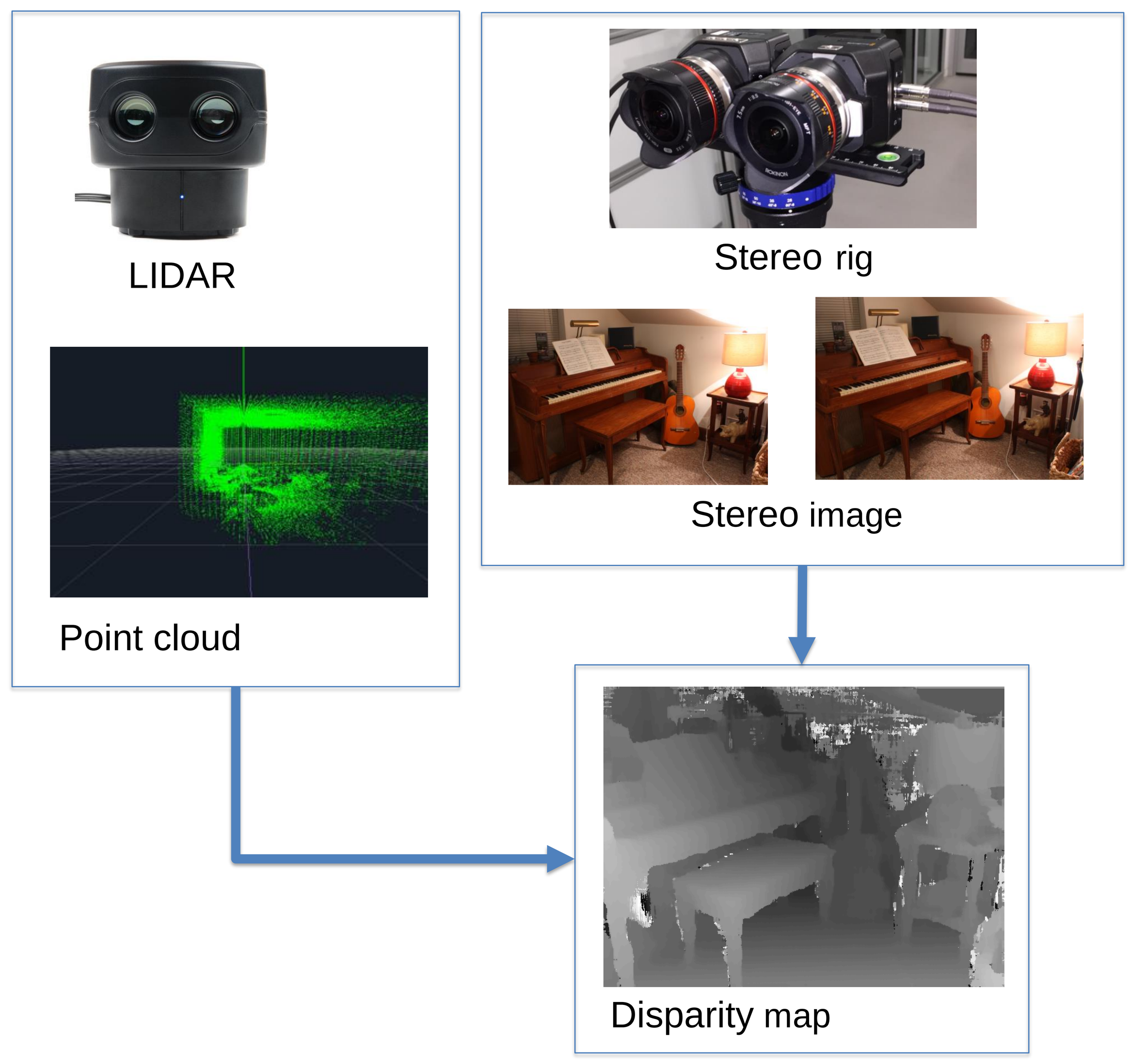

Fig. 2 Data flow of the proposed method

Equation (1) is used to compute the matching cost for a given point and disparity value. This energy function value is to be computed only if $|d_n - \mu| < 3\sigma$ or d is an element of the neighboring support point disparities.

$$E(d) = \beta(1 - cos(vl, vr)) - \log\left[\gamma + \exp\left(-\frac{[d-\mu(S,o^{(l)})]^2}{2\sigma^2}\right)\right] \quad (1)$$

The first term in (1) takes the cosine distance between the two descriptors with some coefficient β. This is the measure of disparity value correctness that is based on graphic information from the images. The second term represents the correctness of the disparity value according to how close it is to the estimated prior disparity obtained with the use of support points grid. $\mu(S, o^{(l)})$ is a piecewise linear function which interpolates the disparities.

RESULTS

Figure 3 shows the graph of error rates when different values of grid stepsize were used. Optimal value is 5 pixels as a trade-off between big error rates and computation time increase.

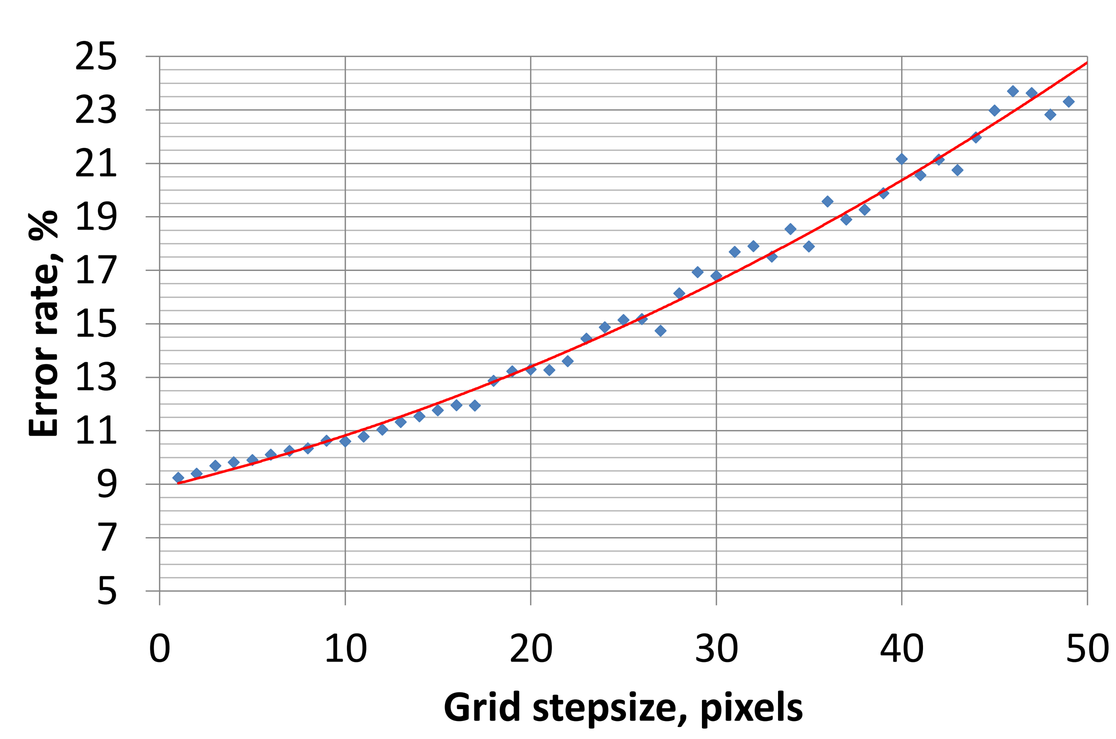

Fig. 3 Error rate dependency on grid stepsize graph

Figure 4 shows the comparison of use of the ELAS method in case of using LIDAR data and a CNN matching cost metric on different images of the Middlebury dataset. The error rate is computed as percentage of pixels for which the obtained disparity differs from the ground truth value by more than 2.

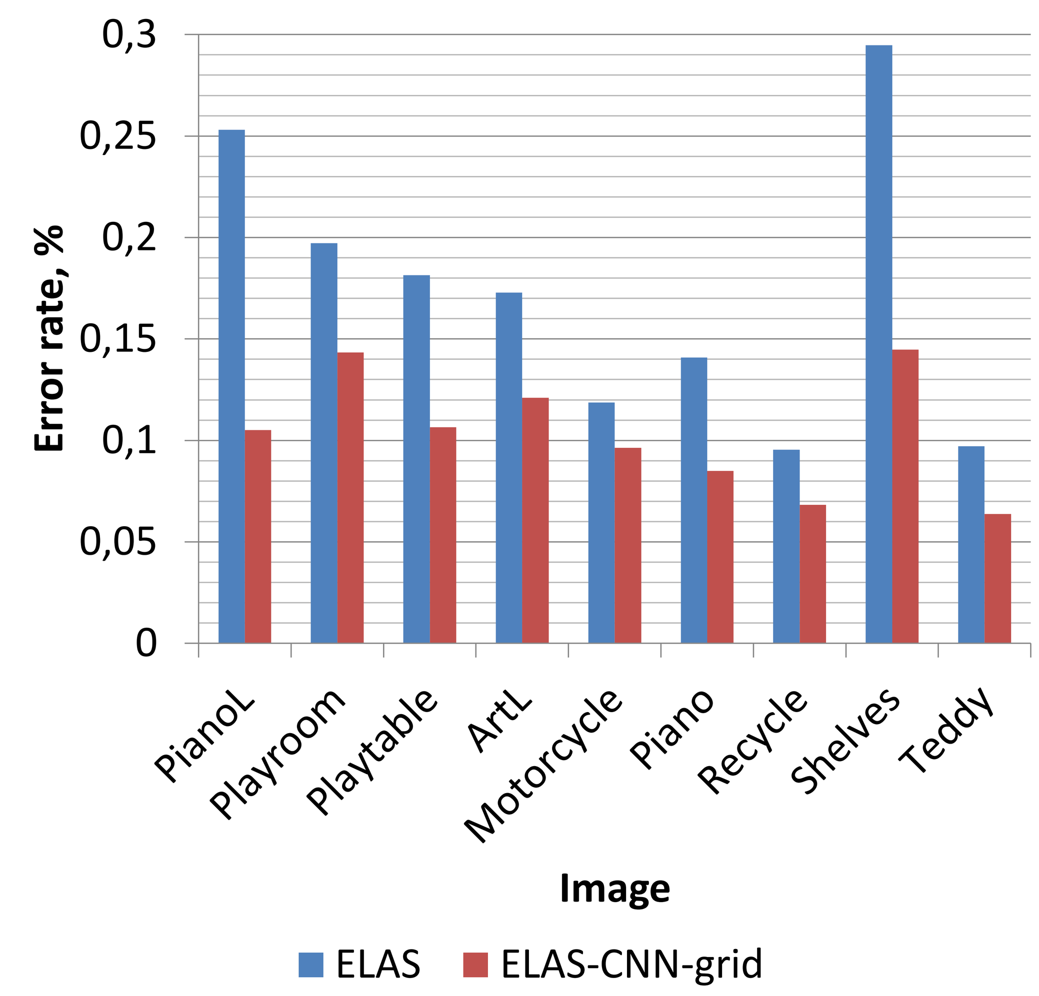

Fig. 4 ELAS and ELAS with CNN metric and LIDAR data comparison

CONCLUSIONS

- **A stereo method that uses a CNN for matching cost computation and LIDAR data as support points was implemented.**
- **Optimal grid stepsize chosen is 5 pixels.**
- **Proposed method was compared with the original ELAS method.**

For ELAS method the use of CNN and LIDAR data reduced the average error by more than 6% and maximum by more than 15%.

Use of LIDAR data for support points grid calculation in stereo matching reduces the error rate up to 15%.

REFERENCES

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[2] Zbontar, J., LeCun, Y. Stereo matching by training a convolutional neural network to compare image patches // J. Mach. Learn. Res. 17, 1. - 2016. P. 2287-2318.