All-season 3D Object Recognition Challenges

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Motivation

Benchmark the discriminative power of 3D feature descriptors for *stereo vision* (Sv) and *Swiss ranger* (Sr) camera using outdoor data recorded daytime, nigh-time, rain and snow.

3D Outdoor object datasets

Outdoor $1-4m$ sized objects in several weather, light conditions. The 8 outdoor objects considered for the SVM classification benchmark for with the two cameras:

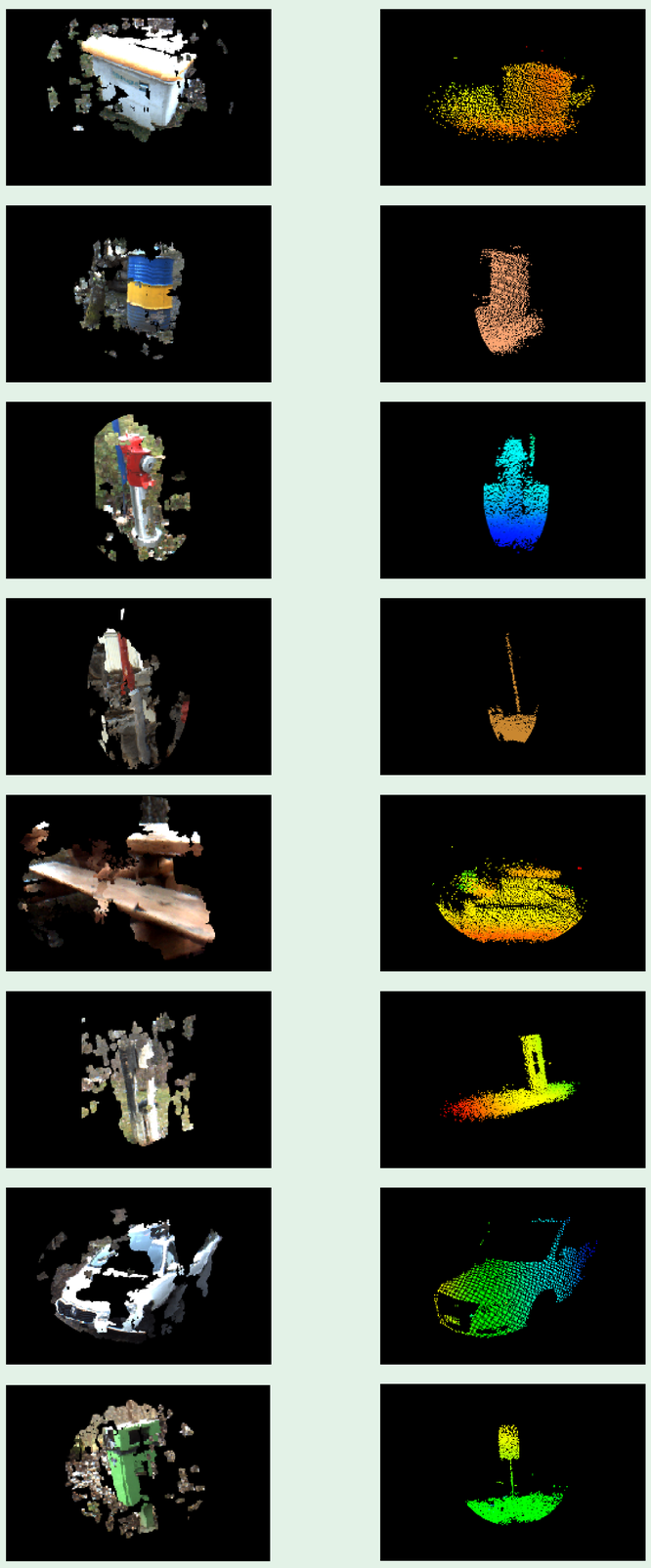

Figure 1: Objects captured with Sv and Sr

Challenging due to the weather/light changes

Figure 2: Box in snow, moonlight, shadow, sun

Stereo vision camera

Pros: returns RGB-D information 5-20Hz, at different ranges
Cons: inefficient for texture-less regions e.g. snow, or poor light conditions e.g. night

Figure 3: Same box at daytime and nightime

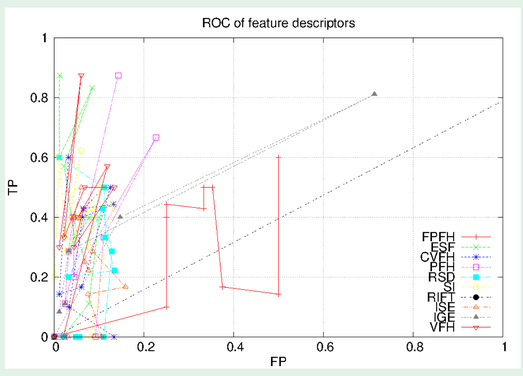

Figure 4: ROC curve for feature descriptors

Swiss ranger depth camera

Pros: gives XYZ-I information 10-20Hz, works at nightime too
Cons: sensible to background ligth conditions (e.g. sunshine)

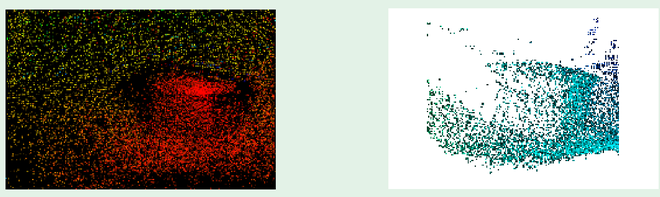

Figure 5: Same box at daytime and nightime

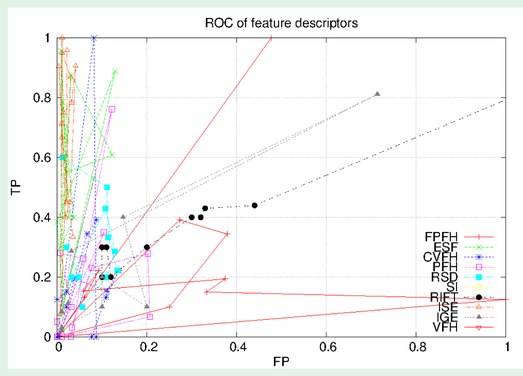

Figure 6: ROC curve for feature descriptors

Benchmarking results

Benchmarked 3D feature descriptors: VFH, CVFH, PFH, FPFH, RSD, RIFT, ISE, IGE, ESF. For the classification the SVM approach was adopted trained-evaluated on the these feature-descriptors.

Descr.	Sv_{day}	$Sr_{nighsnow}$	$Sr_{nightmoon}$	Sr_{day}
VFH	0.55	0.63	0.78	0.44
CVFH	0.61	0.61	0.69	0.51
PFH	0.62	0.56	0.71	0.37
FPFH	0.41	0.46	0.50	0.39
RSD	0.73	0.52	0.77	0.42
RIFT	0.59	0.54	0.69	0.33
SI	0.78	0.64	0.83	0.59
ISE	0.77	0.59	0.83	0.48
IGE	0.64	0.57	0.80	0.42
ESF	0.63	0.65	0.79	0.49

Table 1: Average output SVM classifier for the feature descriptors

Results of the feature descriptor comparison for the SR using the AC_d metrics for the SI type of feature-descriptor:

	box	cyl.	hyd.	sti.	tab.	tru.	car.	t-b.
box	0.3	0.0	0.0	0.1	0.1	0.2	0.1	0.2
cyl.	0.0	0.5	0.0	0.0	0.0	0.1	0.4	0.0
hyd.	0.0	0.1	0.6	0.0	0.0	0.2	0.0	0.0
sti.	0.0	0.0	0.1	0.8	0.0	0.1	0.0	0.0
tab.	0.0	0.1	0.0	0.0	0.5	0.3	0.0	0.2
tru.	0.0	0.0	0.0	0.3	0.1	0.6	0.0	0.0
car.	0.0	0.0	0.1	0.0	0.1	0.3	0.5	0.0
t-b.	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.6

Table 2: Rounded confusion matrix for the test outdoor objects using SVM and SI feature descriptors

Conclusions/future work: SR depth sensor proved to be robust against sevear weather changes for object recognition. As extension, the non-linear deformation modelling of the objects is proposed due to accumalated snow on the top of it.

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