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Evaluation of Background Subtraction Techniques for Video Surveillance

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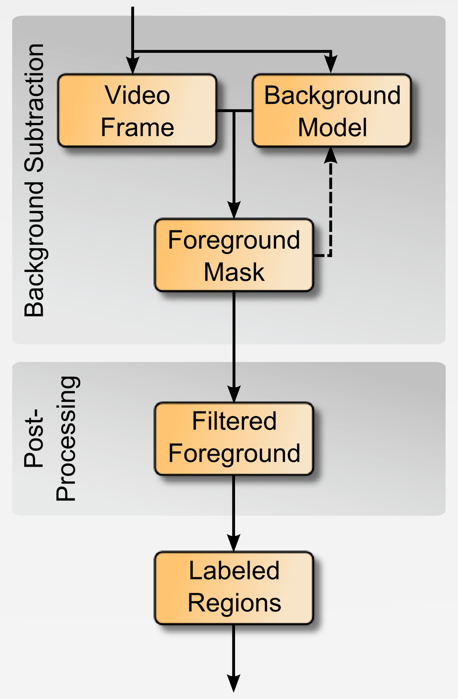
Background Subtraction

Introduction

Problems with existing evaluations:

- Outdated methods
- Few manually annotated frames
- Typical challenges of BS missing
- Challenges are not separated
- Low quality of sequences



Evaluated Methods

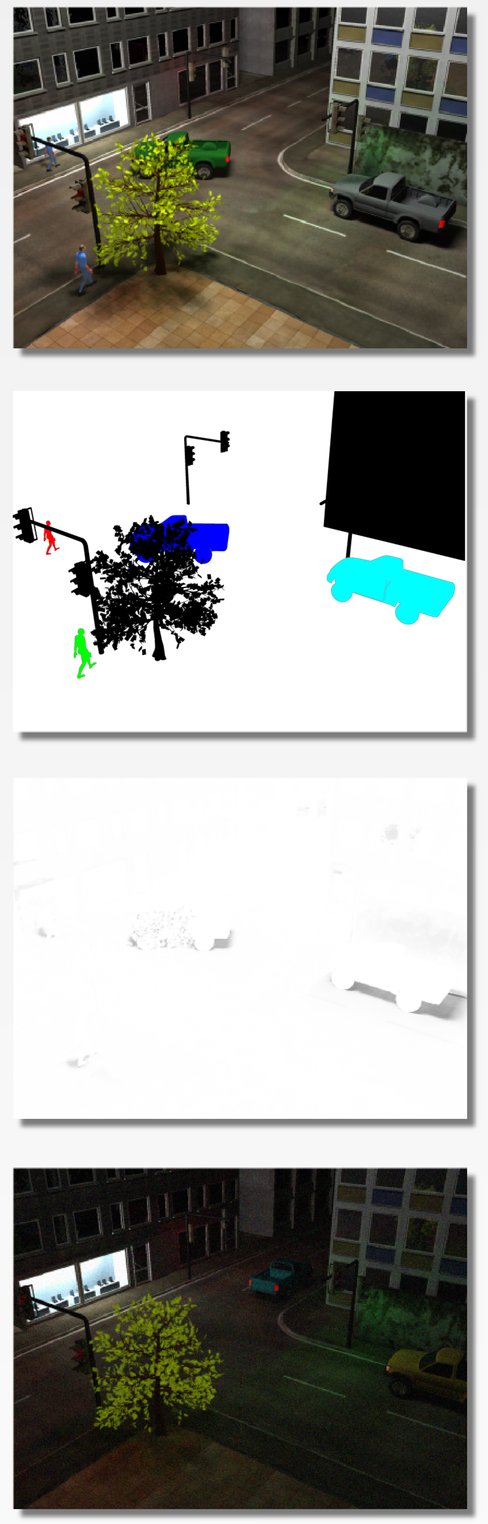
Method	Year	Model Representation	Features	Model Scale	Adaptive	Foreground Detection
McFarlane	1995	Unimodal (median)	Color	Pixel	yes	DM
Stauffer	1999	Multimodal (Gaussian)	Color	Pixel	yes	DM
Oliver	2000	Linear subspace	Pixel correlation (color)	Frame	no	DM
McKenna	2000	Unimodal (Gaussian)	Chromaticity, gradient	Pixel	yes	DM
Li	2003	Non-parametric (discretized)	Color, color-cooccurence	Pixel	yes	FD, DM
Kim	2004	Multimodal (codeword)	Color, luminance	Pixel	yes	DM
Zivkovic	2006	Multimodal (Gaussian)	Color	Pixel	yes	DM
Maddalena	2008	Multimodal (mean)	Color	Pixel*	yes	DM
Barnich	2009	Non-parametric, non-recursive	Color	Pixel*	yes	DM

* Per pixel model, but with regional diffusion in update step, DM = Difference to model, FD = Frame difference

Main Challenges

- Gradual illumination changes
- Sudden illumination changes
- Dynamic background
- Camouflage
- Shadows
- Bootstrapping
- Sensor noise
- Coding artefacts

Artificial Dataset & Evaluation



Dataset

- Synthetic high quality 3D models
- Realistic illumination (Mental Ray/Autodesk Maya)
- Typical video surveillance setting:
  - Fixed viewpoint
  - Additive Gaussian sensor noise
- 7 sequences covering 9 challenge scenarios
- Substantial amount of training and test data:
  800 frames training, 600 frames testing (800x600px)
- High quality pixel-level ground-truth (Maya Vector)
- Shadow masks (light differences)
- Matlab evaluation framework

Evaluation Setup

- 9 background subtraction challenges
- Different pixel-wise post-processing methods
- Test with optimal parameters

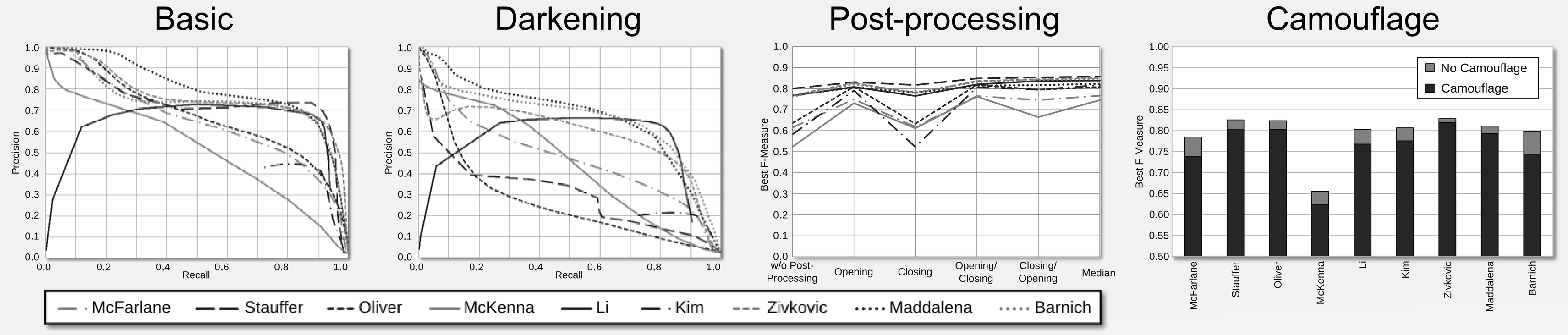
Findings

- Most promising: Li, Zivkovic, Maddalena, **Barnich**
- Weak approaches benefit most from post-processing
- Trend: regional diffusion of background information
- Methods fail on demanding experiments

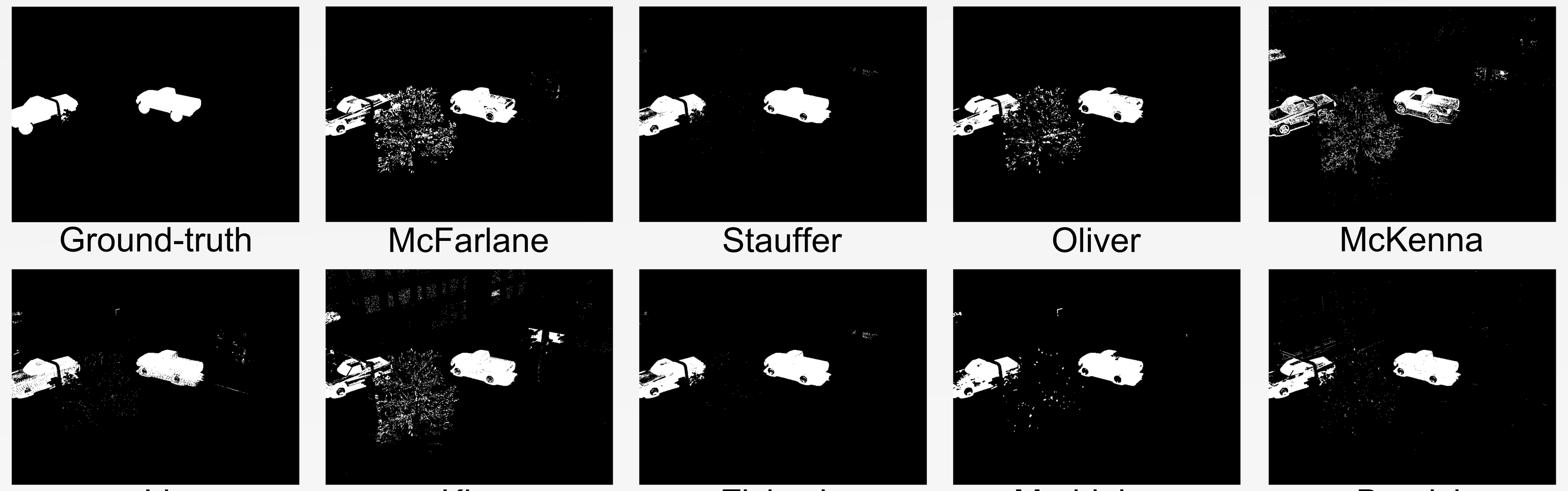
http://www.vis.uni-stuttgart.de/index.php?id=sabs

Results

Charts



Visual Results



Ground-truth, McFarlane, Stauffer, Oliver, McKenna
Li, Kim, Zivkovic, Maddalena, Barnich

Summary

Method	*Basic*	Dynamic Background	*Bootstrap*	Darkening	*Light Switch*	Noisy Night	*Camouflage*	H.264 (40kbps)
McFarlane	0.614	0.482	0.541	0.496	0.211	0.203	0.738	0.639
Stauffer	**0.800**	0.704	0.642	0.404	0.217	0.194	0.802	0.761
Oliver	0.635	0.552	-	0.300	0.198	0.213	0.802	0.669
McKenna	0.522	0.415	0.301	0.484	0.306	0.098	0.624	0.492
Li	0.766	0.641	0.678	**0.704**	**0.316**	0.047	0.768	0.773
Kim	0.582	0.341	0.318	0.342	-	-	0.776	0.551
Zivkovic	0.768	0.704	0.632	0.620	0.300	**0.321**	**0.820**	0.748
Maddalena	0.766	**0.715**	0.495	0.663	0.213	0.263	0.793	0.772
Barnich	0.761	0.711	**0.685**	0.678	0.268	0.271	0.741	**0.774**

Maximal F-Measures (averaged over sequence)

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