REAL-TIME SEMANTIC BACKGROUND SUBTRACTION

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Special Session on "Dynamic Background Reconstruction / Subtraction for Challenging Environments"

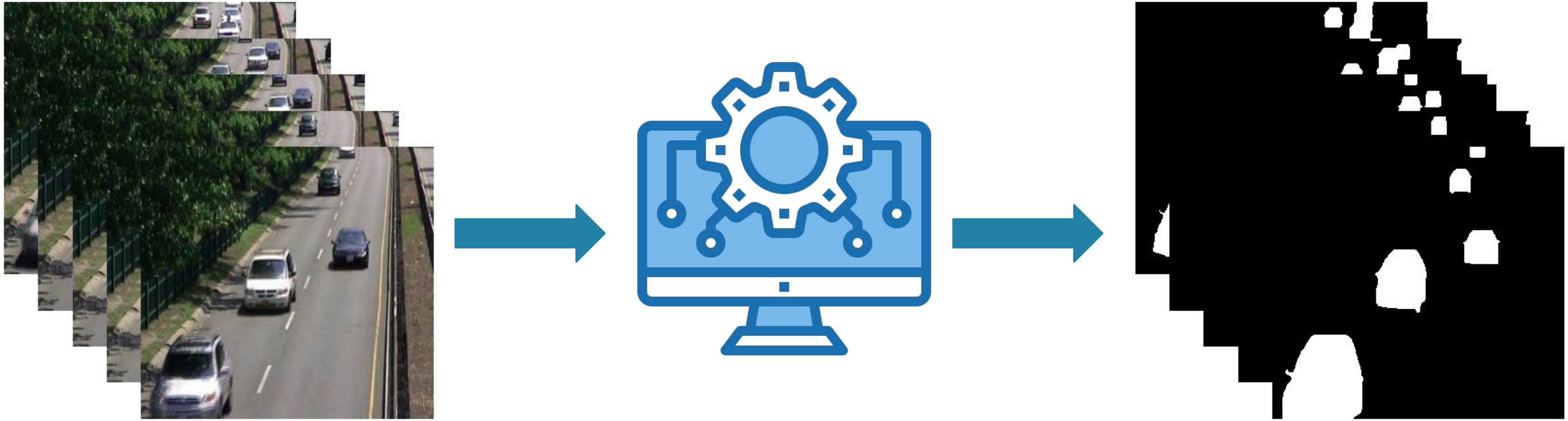
Real-time semantic background subtraction

For a more dynamic presentation of this work, please check our YouTube video!

bit.ly/RT-SBS

Our Channel - ACAD Research
bit.ly/AcadAI

Background subtraction in video sequences

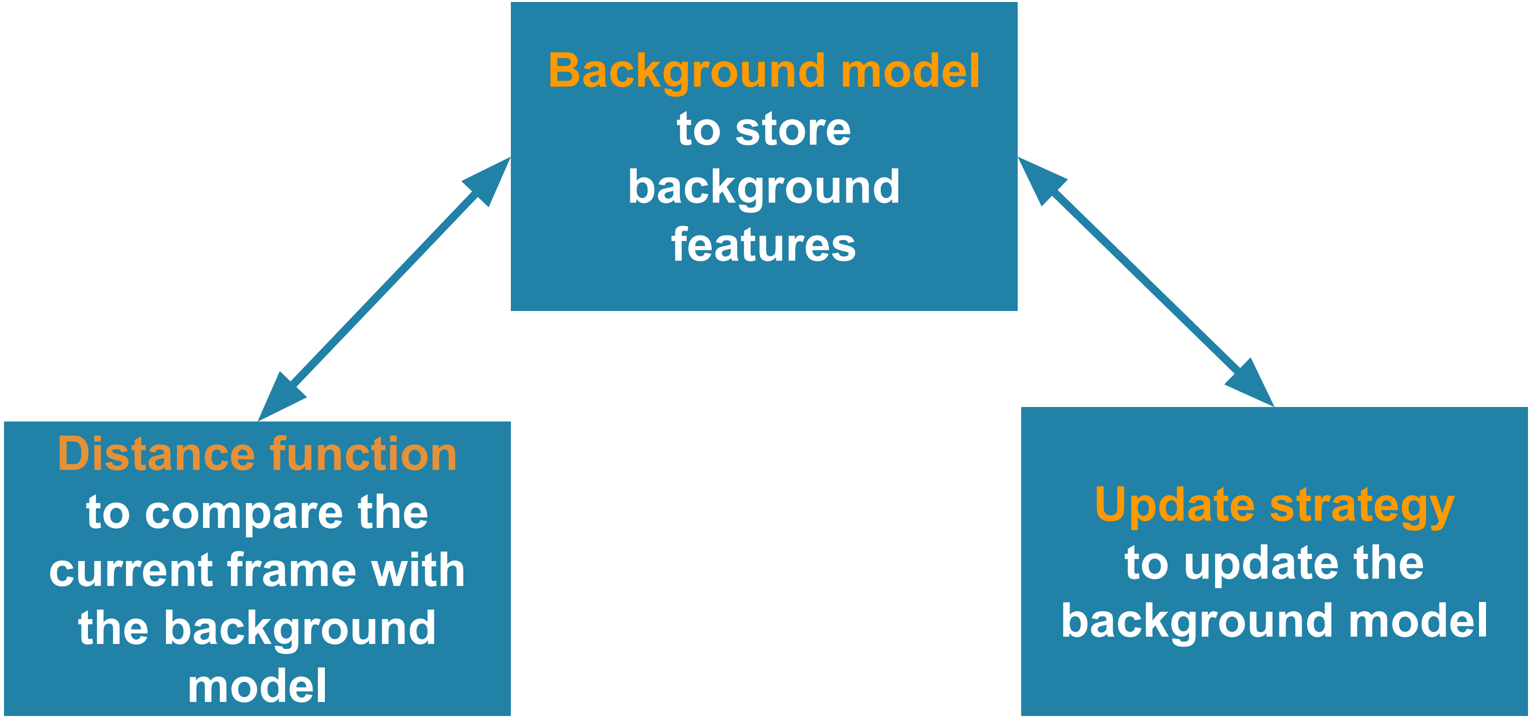


Input video

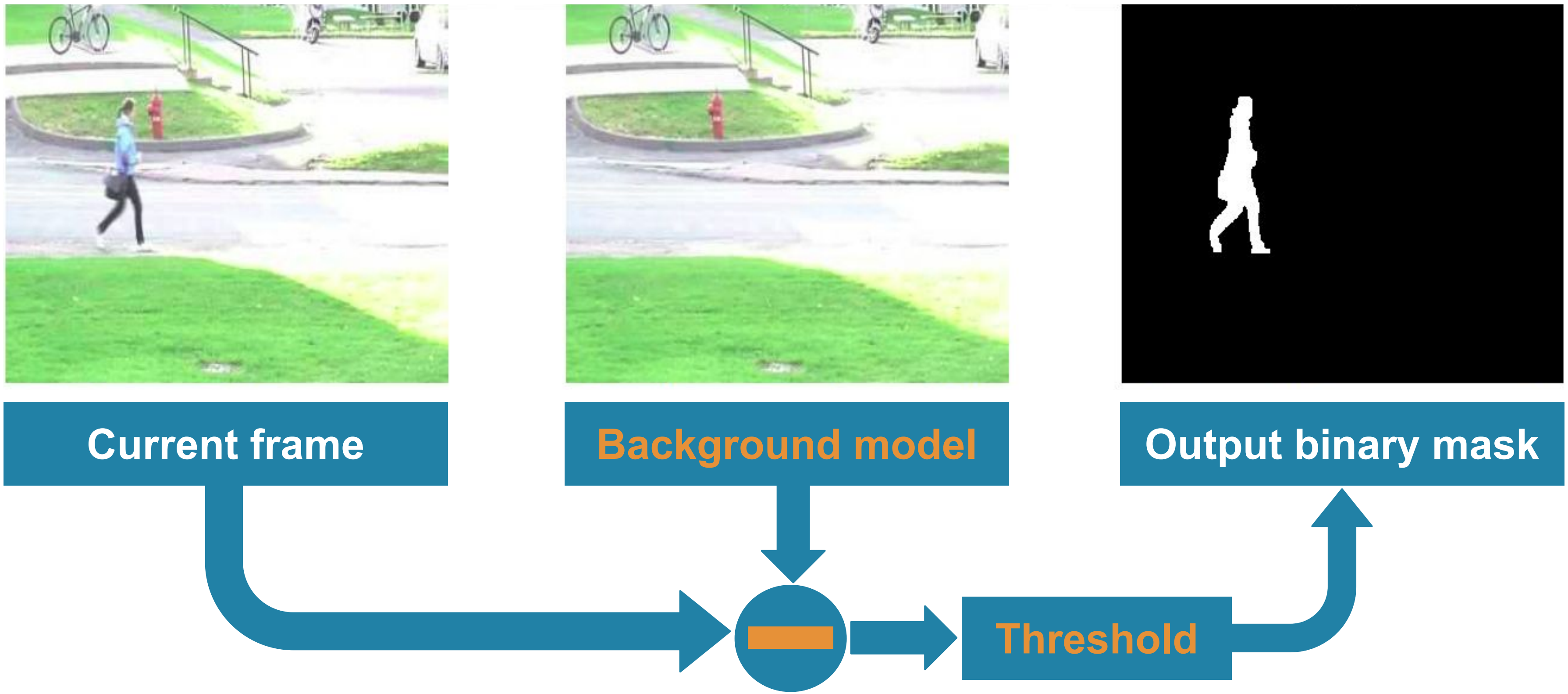
BGS algorithm

Output masks

Principle of BGS algorithms



Principle of BGS algorithms



Typical challenges and traditional solutions

Typical challenges

Color camouflage

Light changes

Dynamic backgrounds

Shadows

...

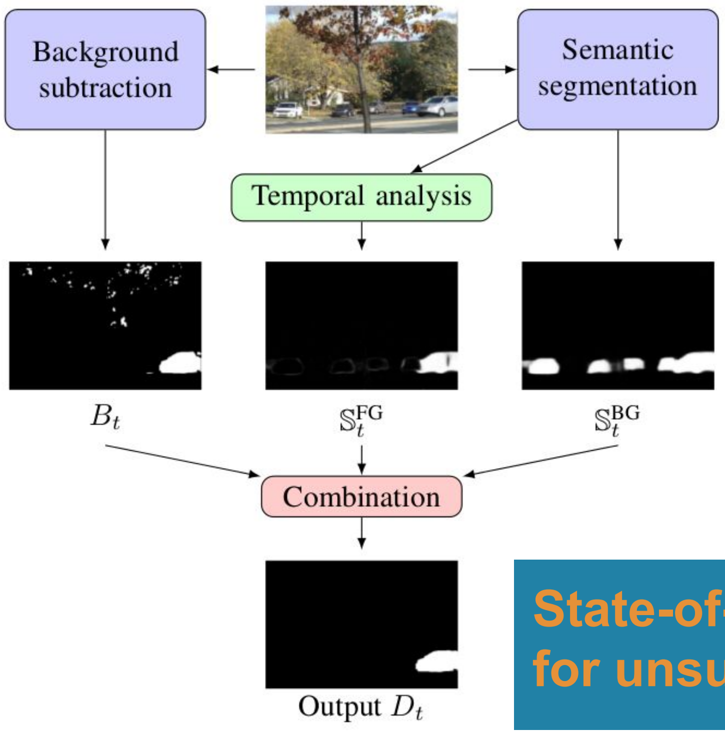
Traditional solutions

Complex background modeling strategies (GMM, KDE, Codebook, ViBe, …)

Sophisticated hand-crafted features (LBP, LBSP, HRI, …)

More recently : deep learning

Semantic background subtraction (SBS)

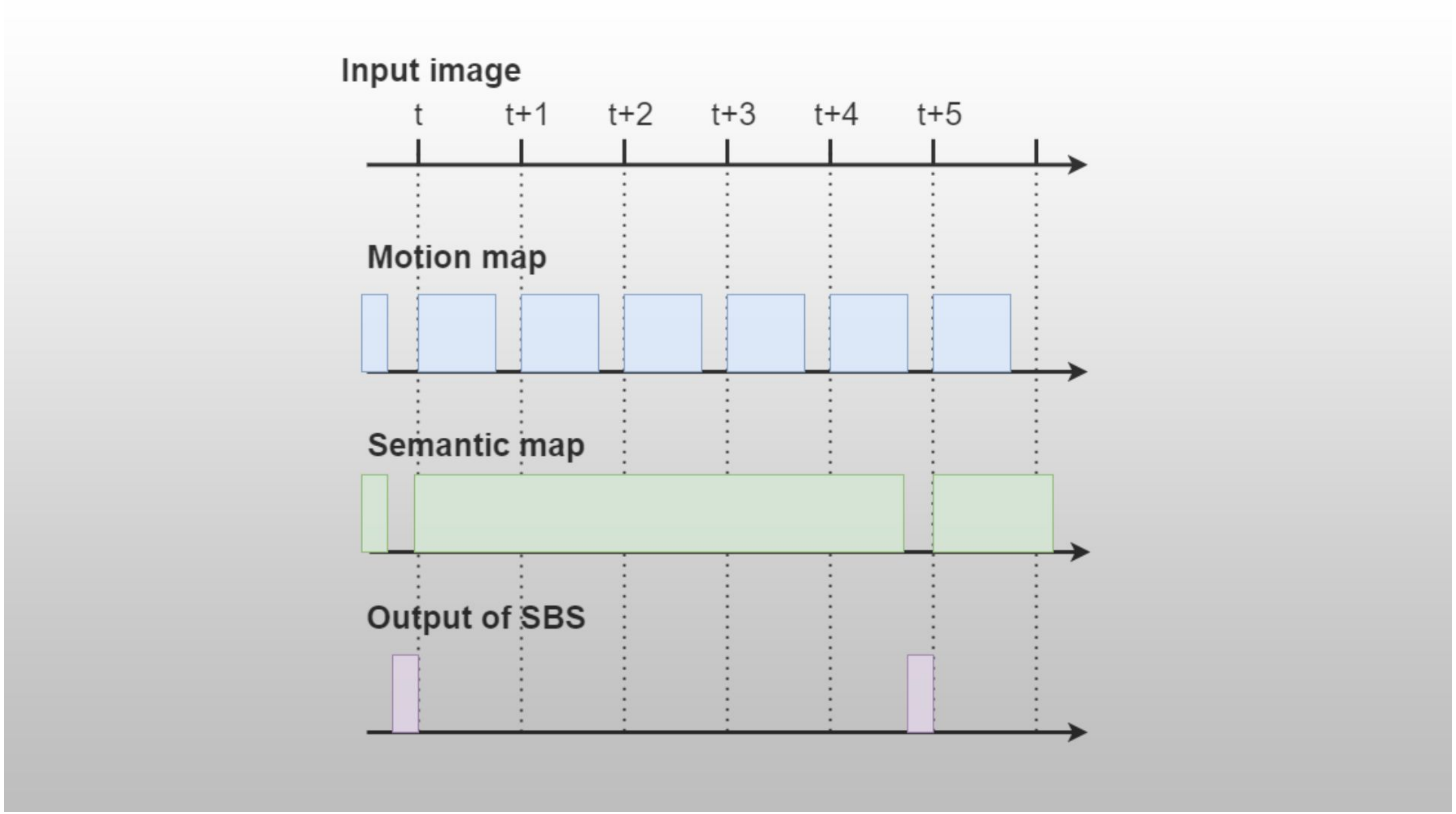


	Decision table of SBS		
	Classifiers		**Output**
	$B_t(x,y)$	$S_t(x,y)$	$D_t(x,y)$
(L1)	BG	"?"	BG
(L2)	BG	BG	BG
(L3)	BG	FG	FG
(L4)	FG	"?"	FG
(L5)	FG	BG	BG
(L6)	FG	FG	FG

State-of-the-art classification performance for unsupervised BGS on the CDNet 2014 dataset.

Braham *et al.*, Semantic background subtraction, ICIP 2017.

Time diagram of SBS



Practical difficulty with SBS

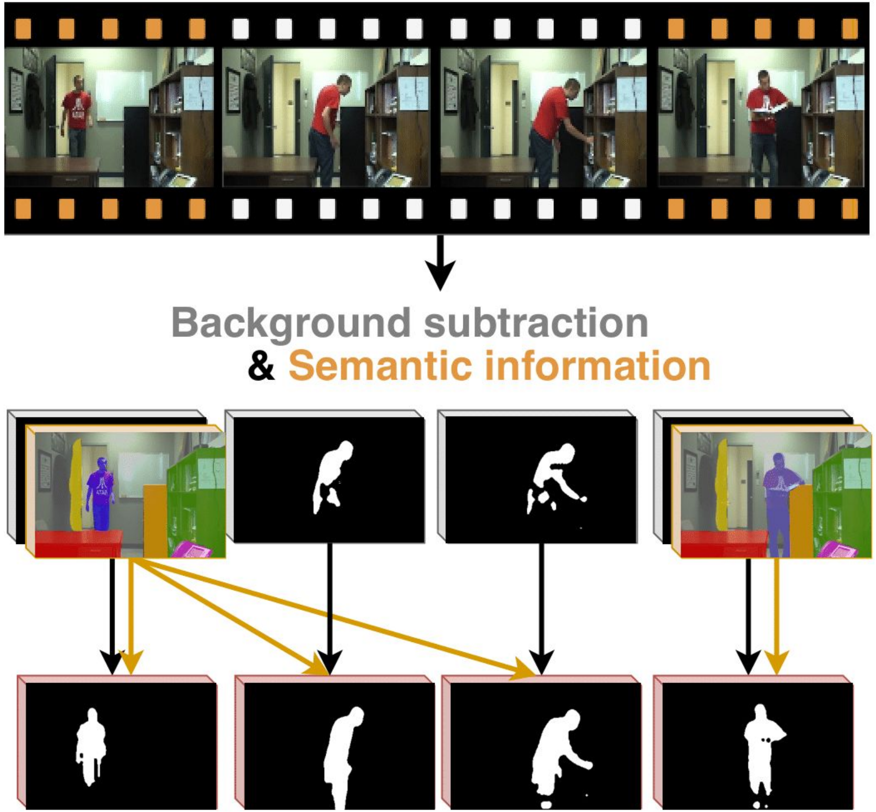
SBS requires a semantic segmentation map for each frame

But...

The best semantic segmentation networks	Lower performances are obtained with
are not real-time	the fastest semantic segmentation networks

How can we obtain high-quality segmentation maps for BGS in real-time?

Real-time semantic background subtraction (RT-SBS)



Decision table of RT-SBS

Key idea for missing semantics:

Reuse previous semantic decision

if pixel color hasn't changed too much!

	Decision table of RT-SBS			
	Classifiers			**Output**
	$B_t(x,y)$	$S_{t^*}(x,y)$	$C_t(x,y)$	$D_t(x,y)$
(L1)	BG	"?"	"✖"	BG
(L2)	BG	BG	"✖"	BG
(L3)	BG	FG	No Change	FG
(L4)	BG	FG	Change	BG
(L5)	FG	"?"	"✖"	FG
(L6)	FG	BG	No Change	BG
(L7)	FG	BG	Change	FG
(L8)	FG	FG	"✖"	FG

Decision table of RT-SBS

The pixel color change at time *t*, ***$C_t(x,y)$***, is computed by a threshold on the **Manhattan distance** between the pixel **current color value** and its **previous color value** when semantic information was last available.

Decision table of RT-SBS				
	Classifiers			**Output**
	$B_t(x,y)$	$S_{t^*}(x,y)$	$C_t(x,y)$	$D_t(x,y)$
(L1)	BG	"?"	"✖"	BG
(L2)	BG	BG	"✖"	BG
(L3)	BG	FG	No Change	FG
(L4)	BG	FG	Change	BG
(L5)	FG	"?"	"✖"	FG
(L6)	FG	BG	No Change	BG
(L7)	FG	BG	Change	FG
(L8)	FG	FG	"✖"	FG

Decision table of RT-SBS

Foreground and background have **different color dynamics.**

Hence, the **threshold** used to compute $C_t(x,y)$ **depends on** $S_{t^*}(x,y)$**.**

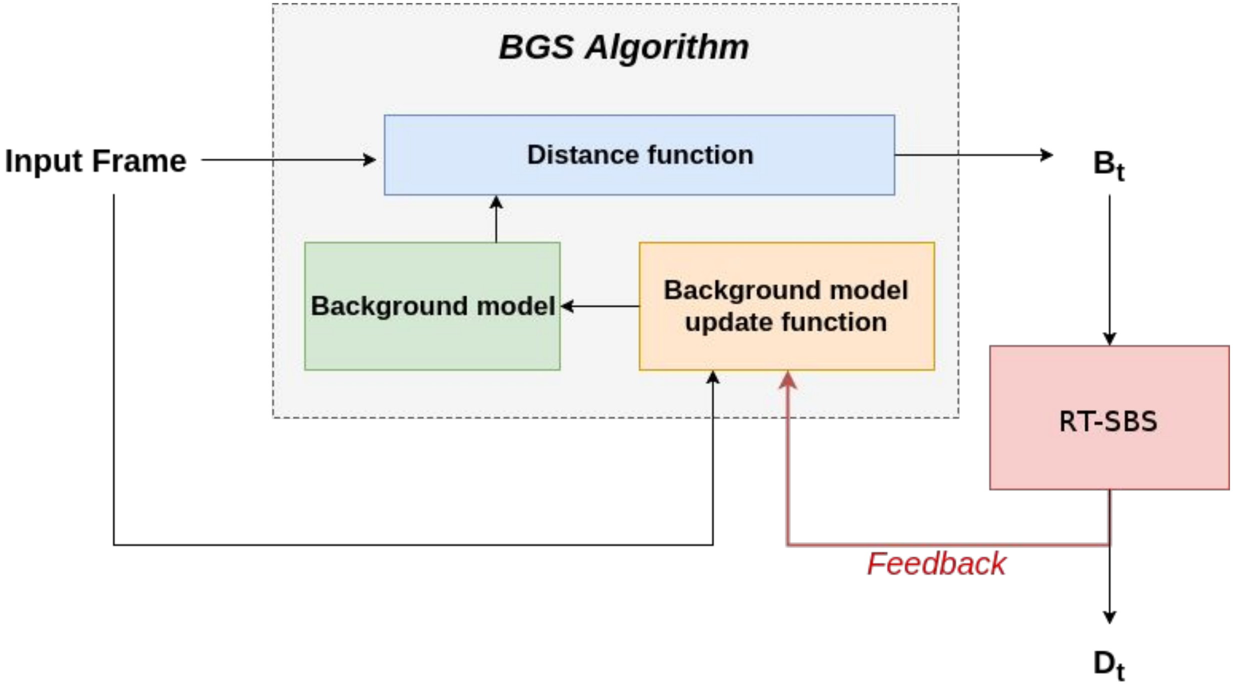
	Decision table of RT-SBS			
	Classifiers			**Output**
	$B_t(x,y)$	$S_{t^*}(x,y)$	$C_t(x,y)$	$D_t(x,y)$
(L1)	BG	"?"	"✖"	BG
(L2)	BG	BG	"✖"	BG
(L3)	BG	FG	No Change	FG
(L4)	BG	FG	Change	BG
(L5)	FG	"?"	"✖"	FG
(L6)	FG	BG	No Change	BG
(L7)	FG	BG	Change	FG
(L8)	FG	FG	"✖"	FG

Improving the BGS algorithm with a feedback loop

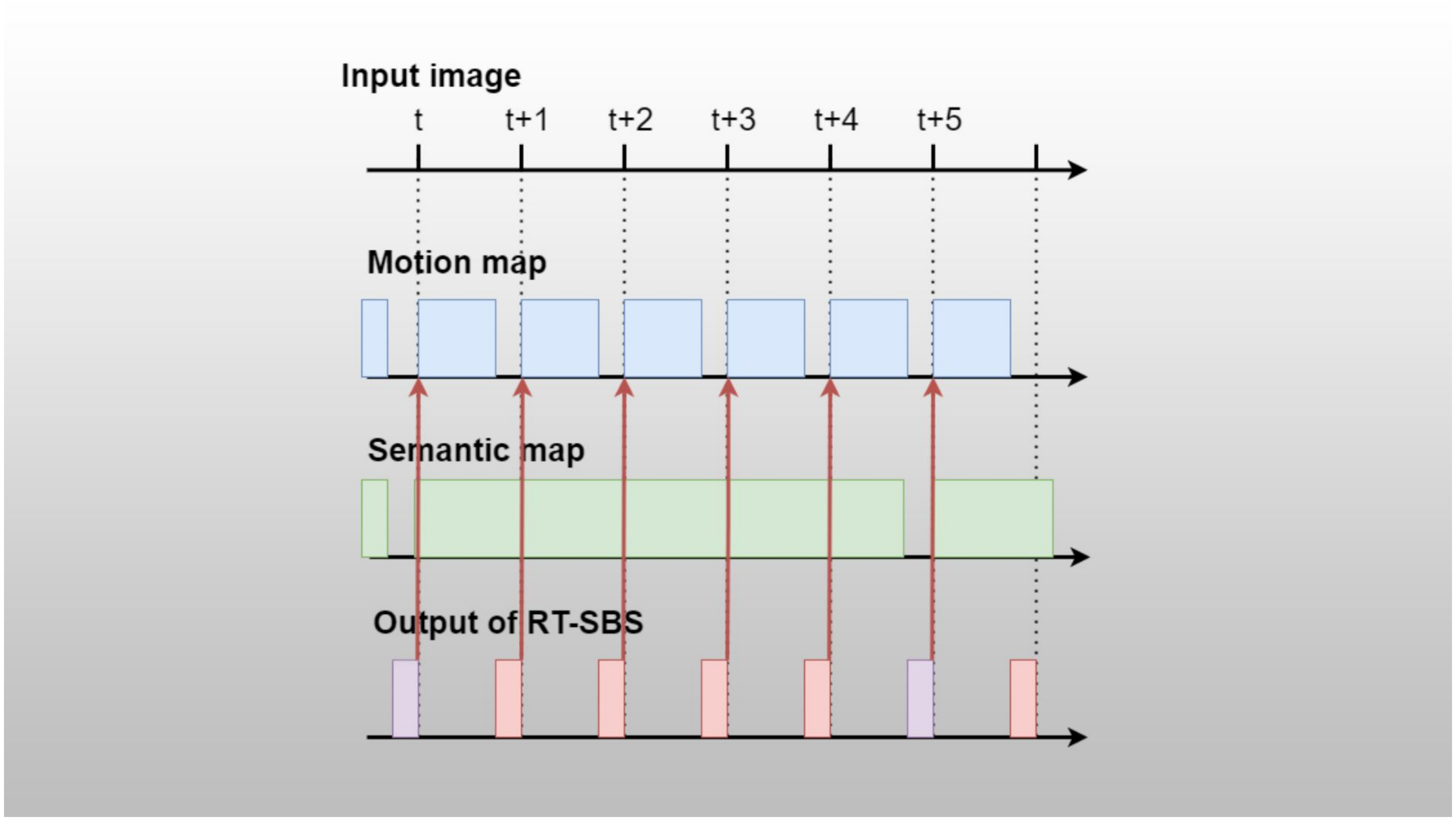
We use **ViBe** as BGS algorithm as it is the **best real-time** one.

We add a **feedback loop** to upgrade ViBe's decisions.

D_t* replaces *B_t as updating mask for the background model.



Time Diagram of RT-SBS

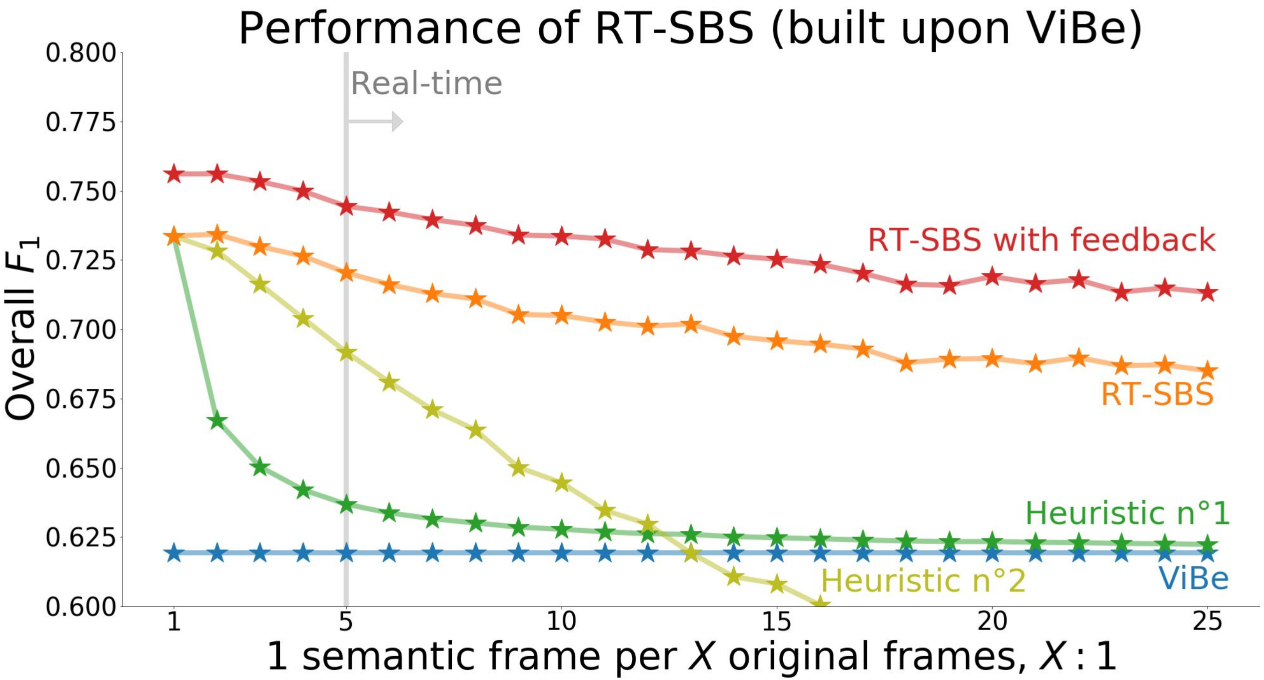


Performance of RT-SBS (built upon ViBe)

Evaluation on the **CDNet 2014** dataset

PSPNet used as semantic segmentation algorithm (~ 5 fps)

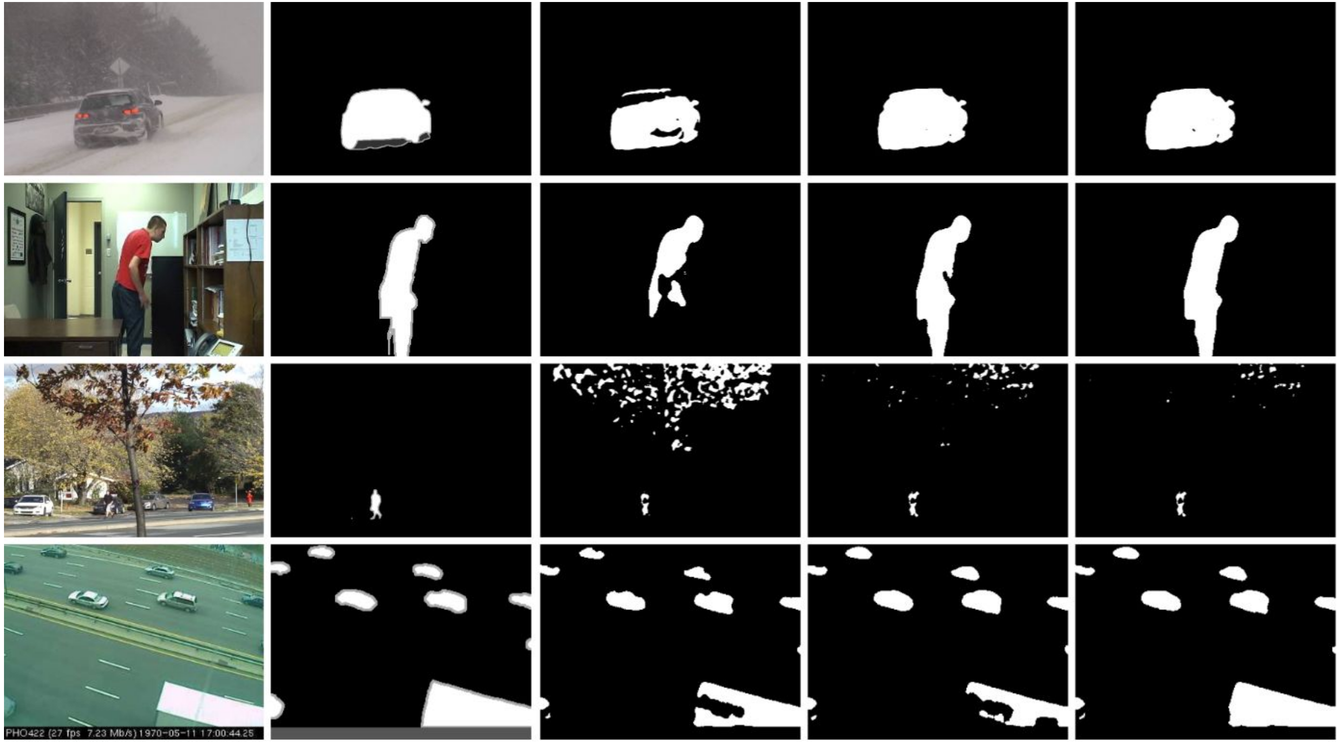
Parameters of RT-SBS optimized to **maximize the overall F_1-score** for each semantic frame rate X.



Comparison with unsupervised BGS algorithms

Unsupervised BGS algorithms	F_1	fps
SemanticBGS (SBS with IUTIS-5) [14]	0.789	≈ 7
IUTIS-5 [9]	0.772	≈ 10
IUTIS-3 [9]	0.755	≈ 10
WisenetMD [20]	0.754	≈ 12
WeSamBE [21]	0.745	≈ 2
PAWCS [22]	0.740	$\approx 1-2$
ViBe [7]	0.619	≈ 152
RT-SBS at $X:5$	0.746	25
RT-SBS at $X:10$	0.734	50
RT-SBS at $X:5$ and scene-specific optimization	**0.828**	**25**

Qualitative results



Input	Groundtruth	ViBe	RT-SBS (no feedback)	RT-SBS (+ feedback)

Conclusion

RT-SBS extends the semantic background subtraction (**SBS**) algorithm **for real-time applications**.

RT-SBS uses high-quality semantic information which can be provided **at any pace** and independently for each pixel and checks its **relevance** through time using a **change detection** algorithm.

RT-SBS outperforms real-time background subtraction **algorithms** and **competes with** the non-real-time **state-of-the-art** ones.

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Python CPU and GPU codes available!

cioppaanthony/rt-sbs

Code in Python for all of our works with easy install procedures on docker.
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