[ASP-DAC 2023] Data-Model-Circuit Tri-Design for Ultra-Light Video Intelligence on Edge Devices

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Data-Model-Circuit Tri-Design for Ultra-Light Video Intelligence on Edge Devices

Background

- The efficiency of “compressed” models are evaluated **without considering the practical hardware platform**, such as low-power FPGAs.

Xilinx Alveo U50@75W

Xilinx ZCU104@5W

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- **Multi-Object Tracking (MOT)** is the focus.

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Method

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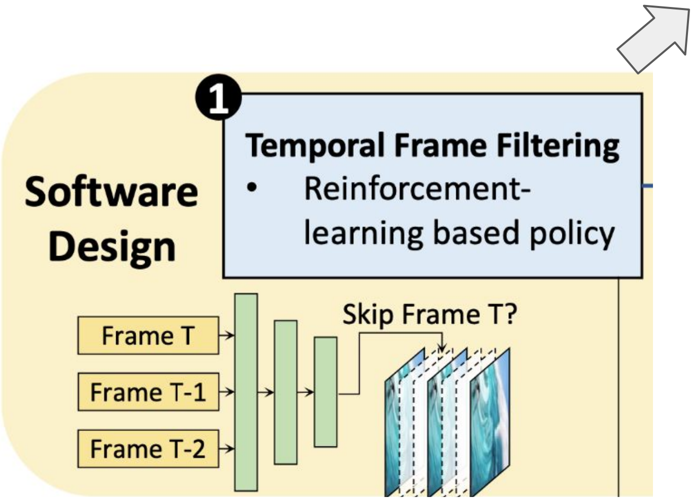
Data



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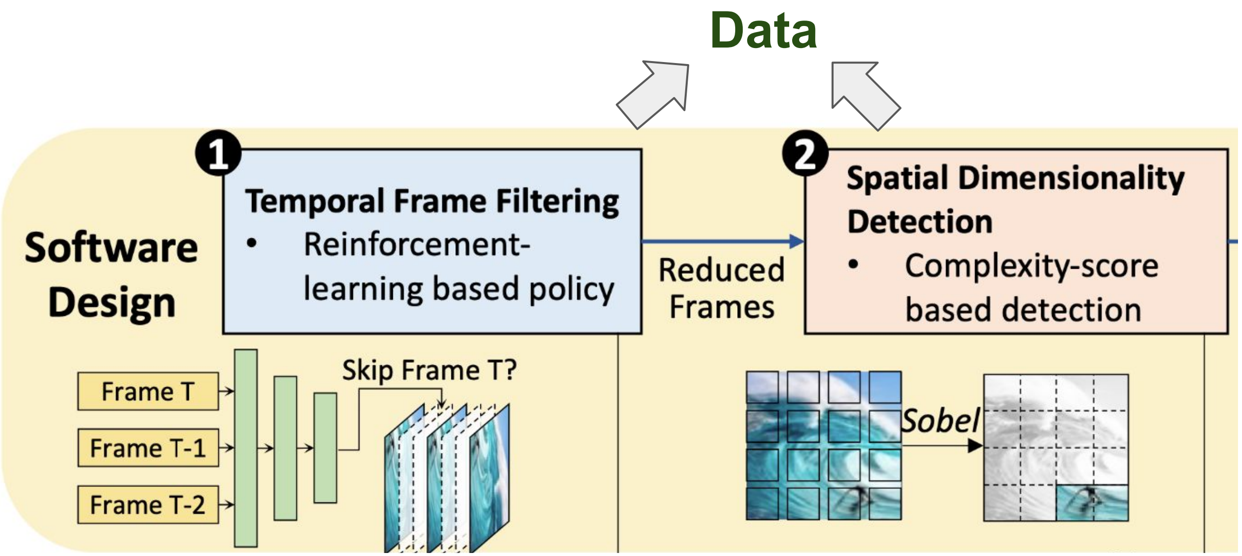

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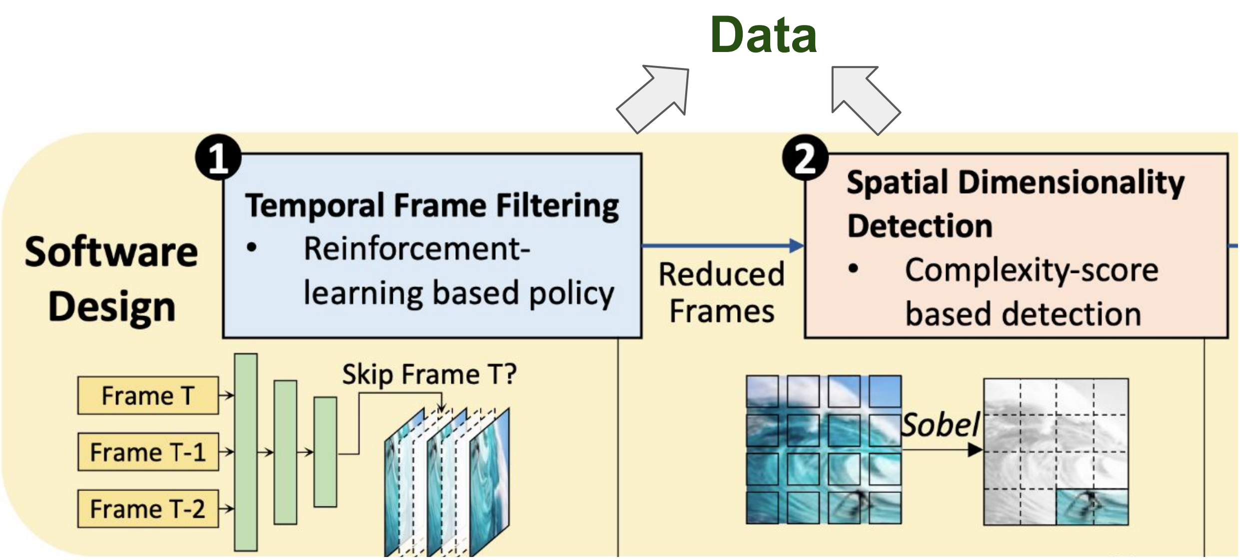

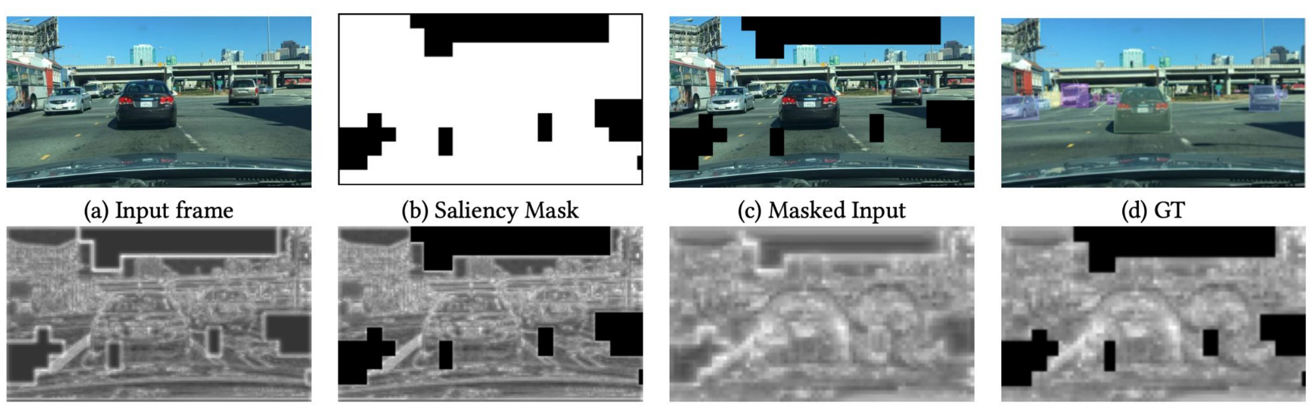

(a) Input frame (b) Saliency Mask (c) Masked Input (d) GT

(e) FM(2,0) (f) FM(2,0) w/ Mask (g) FM(3,0) (h) FM(3,0) w/ Mask

Patch Drop for Input Frame and intermediate features

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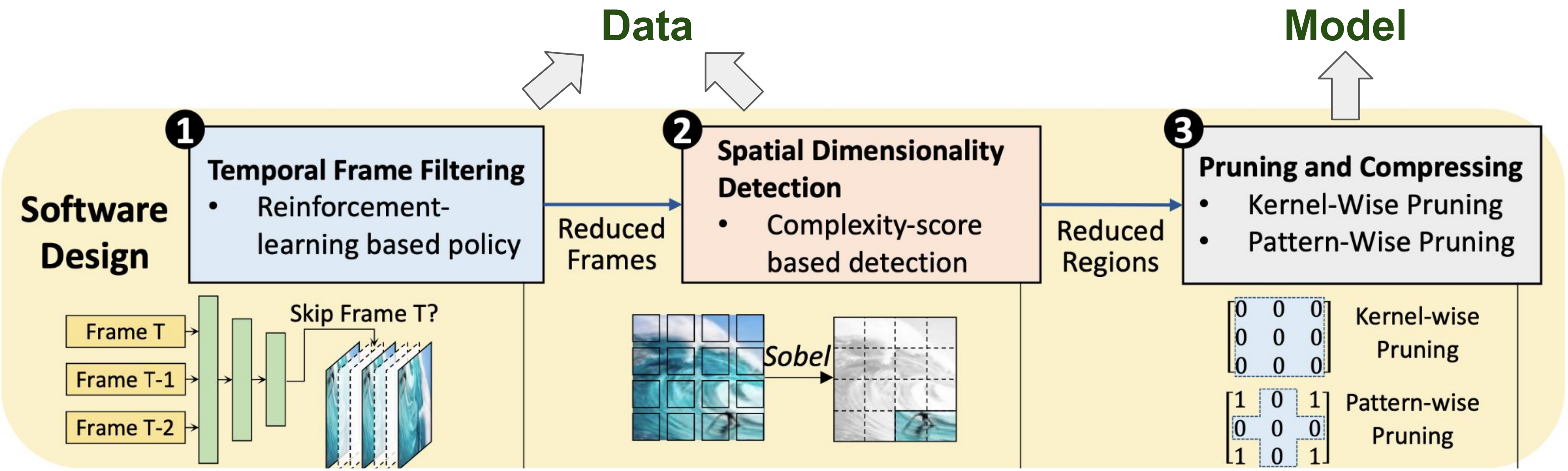

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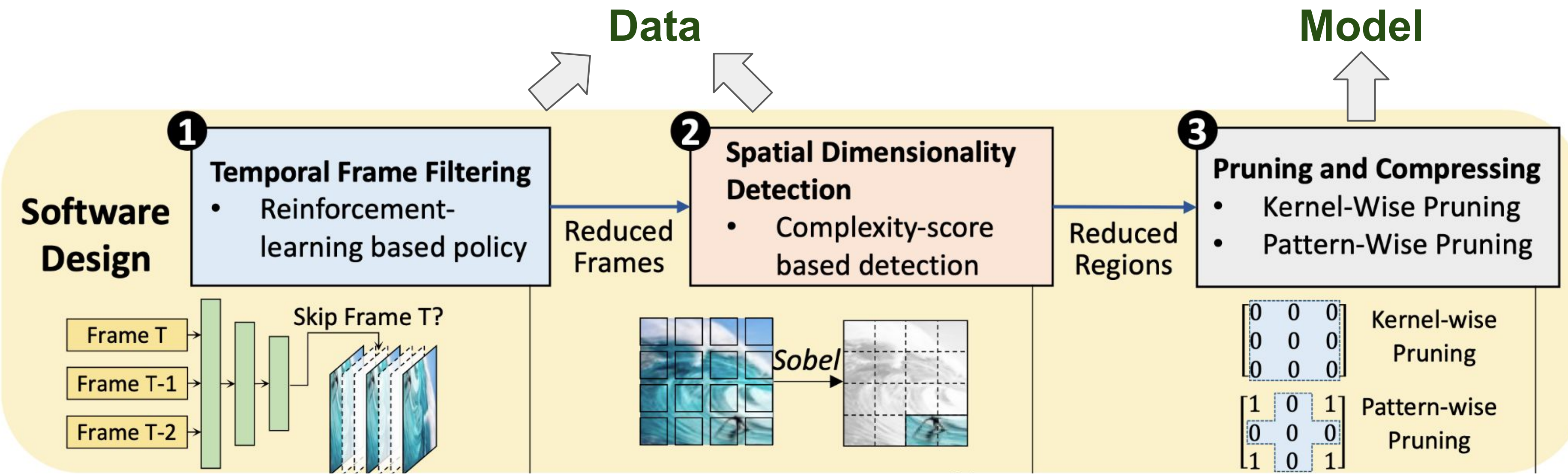

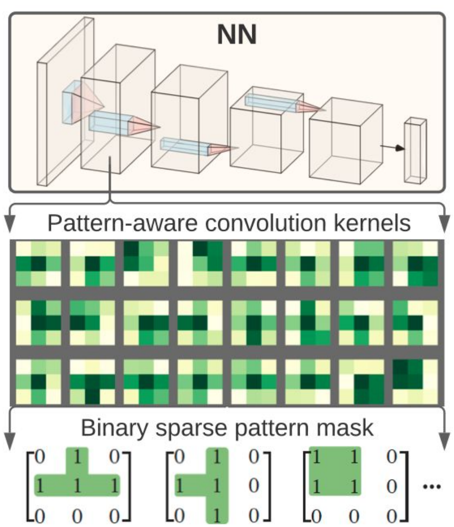

- **pre-define** irregular sparse patterns for 3 × 3 kernels
- leverage them to conduct irregular but **pattern-aware** weight pruning

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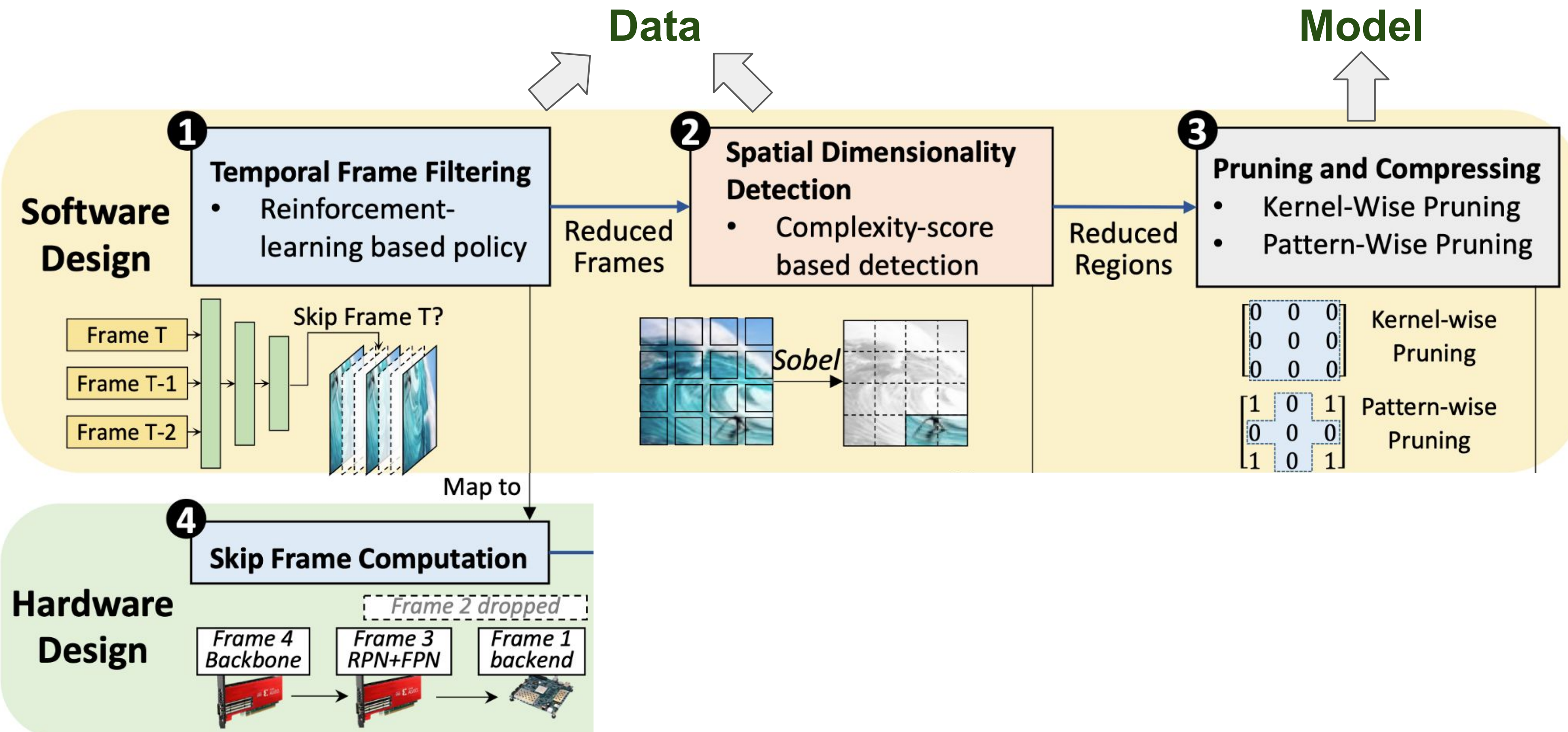

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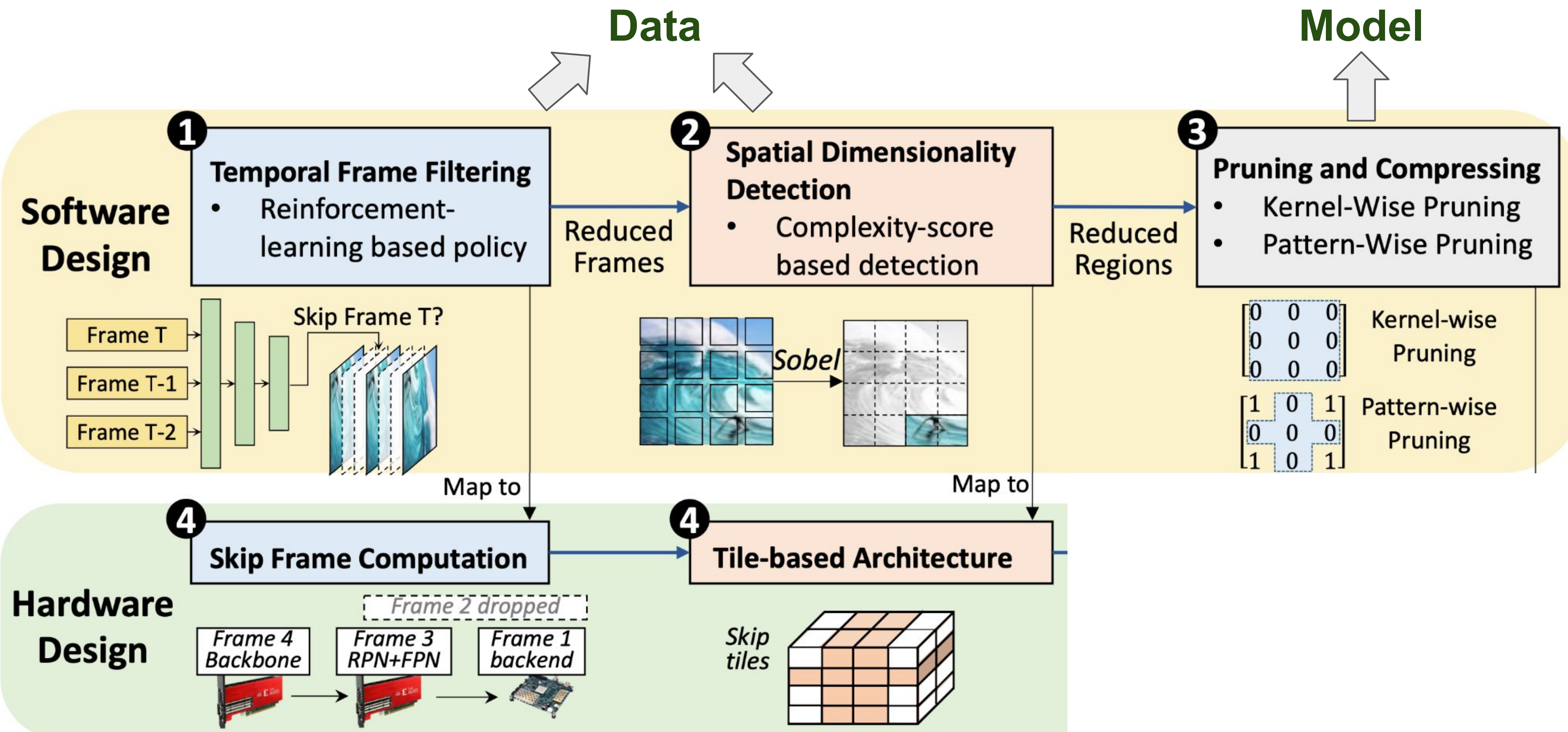

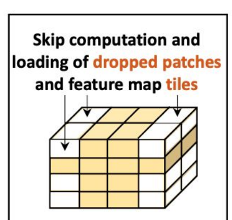

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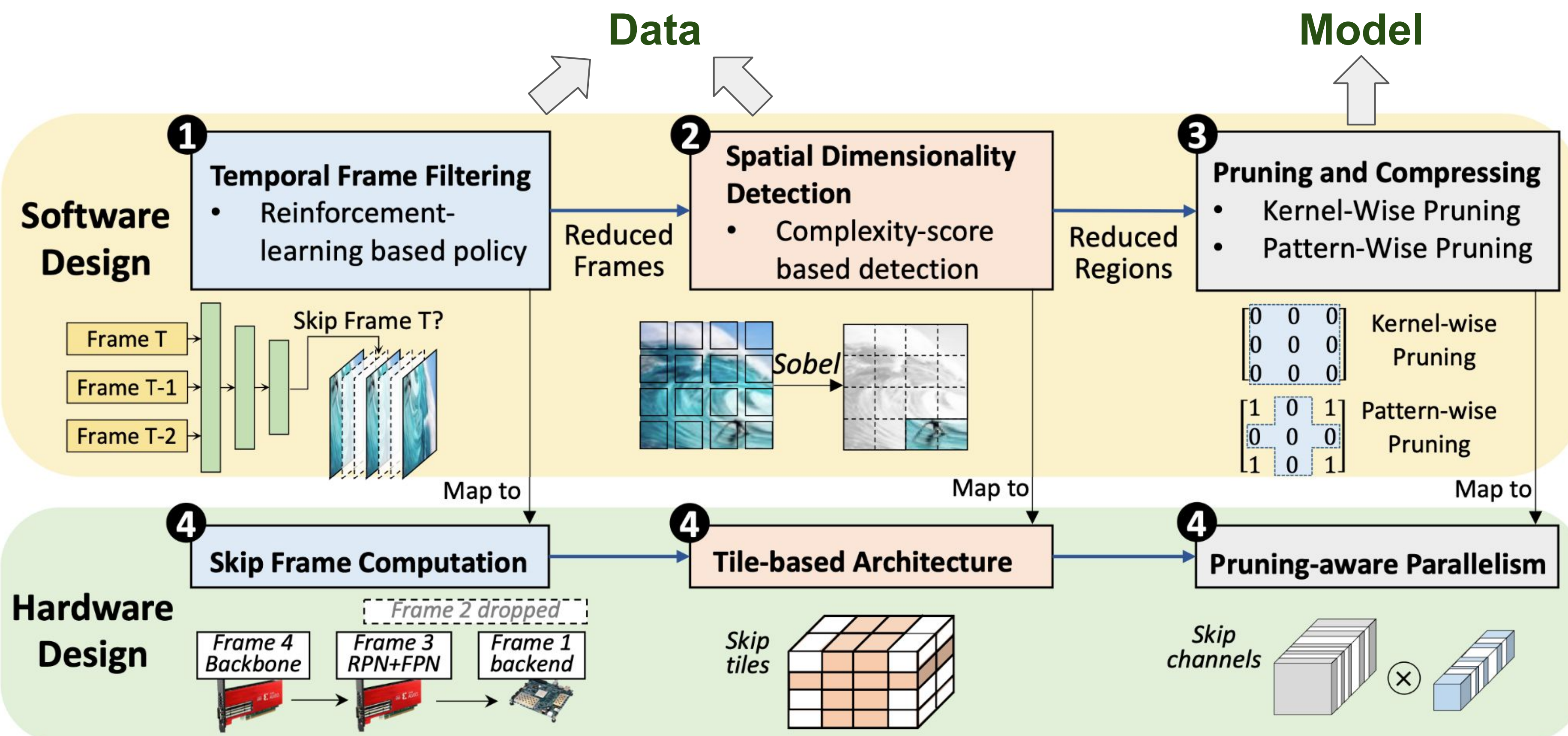

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Performance

Methods	Data/model compression		Metrics					
	Data reduction	Pruning	IDF1 (↑)	MOTA (↑)	Latency (↓)	EFR (↑)	Power (↓)	Energy Efficiency (↓)
QDTrack (GPU baseline)	×	×	0.714	0.637	60.9	22.5	296 W	13.2 J/frame
QDTrack on FPGA	×	×	0.714	0.637	554.7	1.8	50.8 W	28.2 J/frame
Variant: Frame + patch drop	(40%, 20%)	×	0.71	0.628	443.8	2.3	50.8 W	22.0 J/frame
Tri-design (ours)	(40%, 20%)	90%	0.704	0.617	44.4	37.6	50.8 W	1.35 J/frame
Improv. over GPU baseline	—	—	-1.40%	-3.14%	**1.37×**	**1.67×**	**5.83×**	**9.78×**
Improv. over FPGA baseline	—	—	-1.40%	-3.14%	**12.5×**	**20.9×**	—	**20.9×**

Implementation Details

- 40% temporal **frame** dropping
- 20% spatial **patch** dropping
- 90% **model** pruning

Hardware Metrics given by on-board latency in the unit of millisecond

- effective frame rate (**EFR**) → FPS
- **power** in the unit of Watt

Accuracy

- ID F1 Score (**IDF1**)
- Multi-Object Tracking Accuracy (**MOTA**)

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谢谢 ngiyabonga suksema

Met dank
obrigada

Thank You

baie dankie
molte grazie

merci 감사합니다

Danke schön!

obrigado

謝謝

Благодарность شكرًا

dank u

mahalo

gracias

Спасибі Dziękuję

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