

# **Real Time 2-3 Pull-down Elimination Applying Motion Estimation / Compensation on a Programmable Device**

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# Outline of Presentation

- **Why motion compensation?**
- **Prior solution**
- **What's new?**
- **Evaluation**
- **Conclusions**

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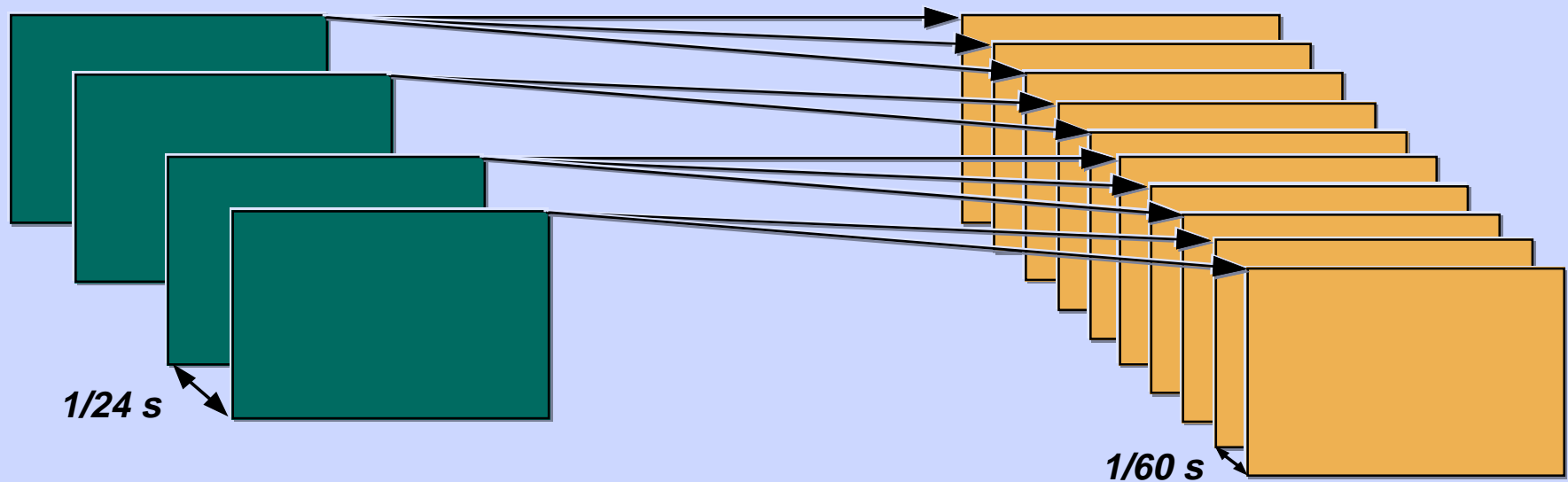
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# Introduction (1)

## *2-3 pull-down*

### Broadcast of 24 Hz movie material



Original movie

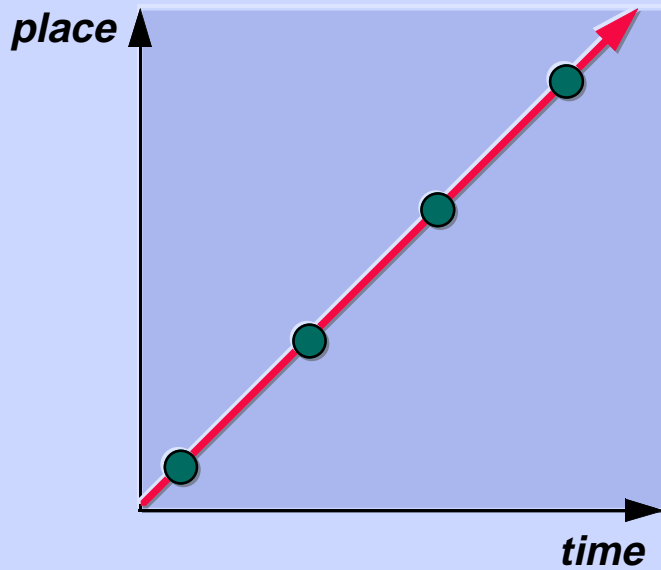
Broadcasted movie

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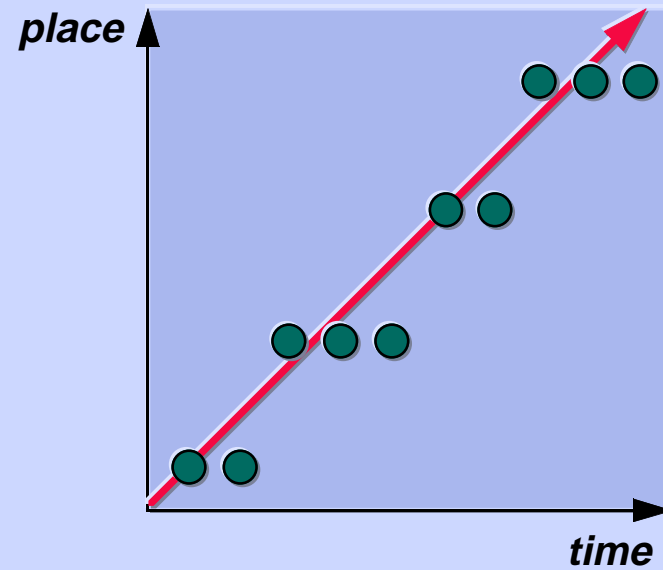
# Introduction (2)

## *2-3 pull-down*

### Implications on moving objects



**Original movie**



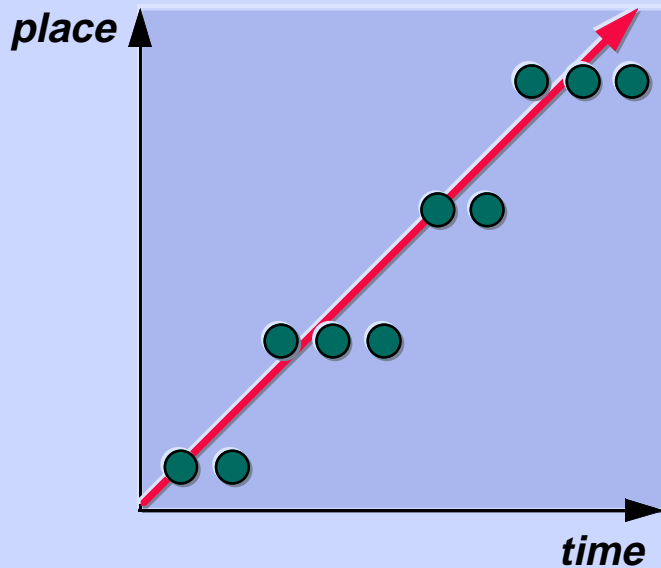
**Broadcasted movie**

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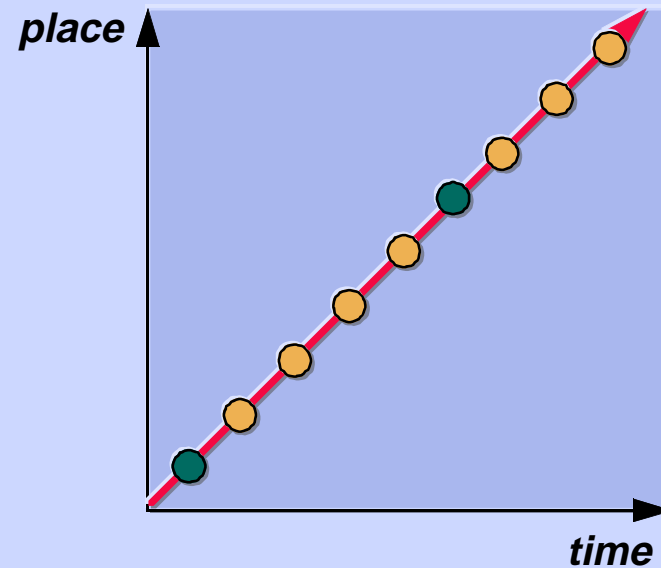
# Introduction (3)

## *2-3 pull-down*

**Solution: motion compensation**



**Broadcasted movie**



**Motion-compensated movie**

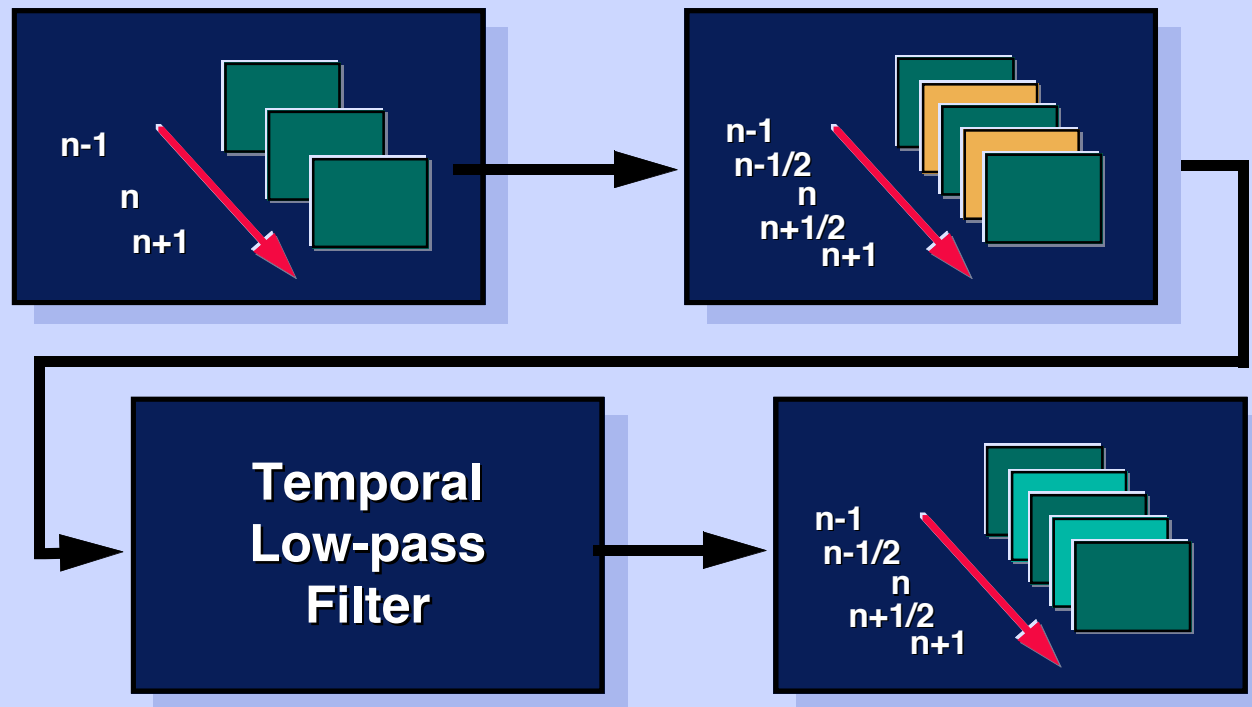
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# Introduction (4)

## *Why motion compensation?*

Linear filtering

*Temporal up-conversion*



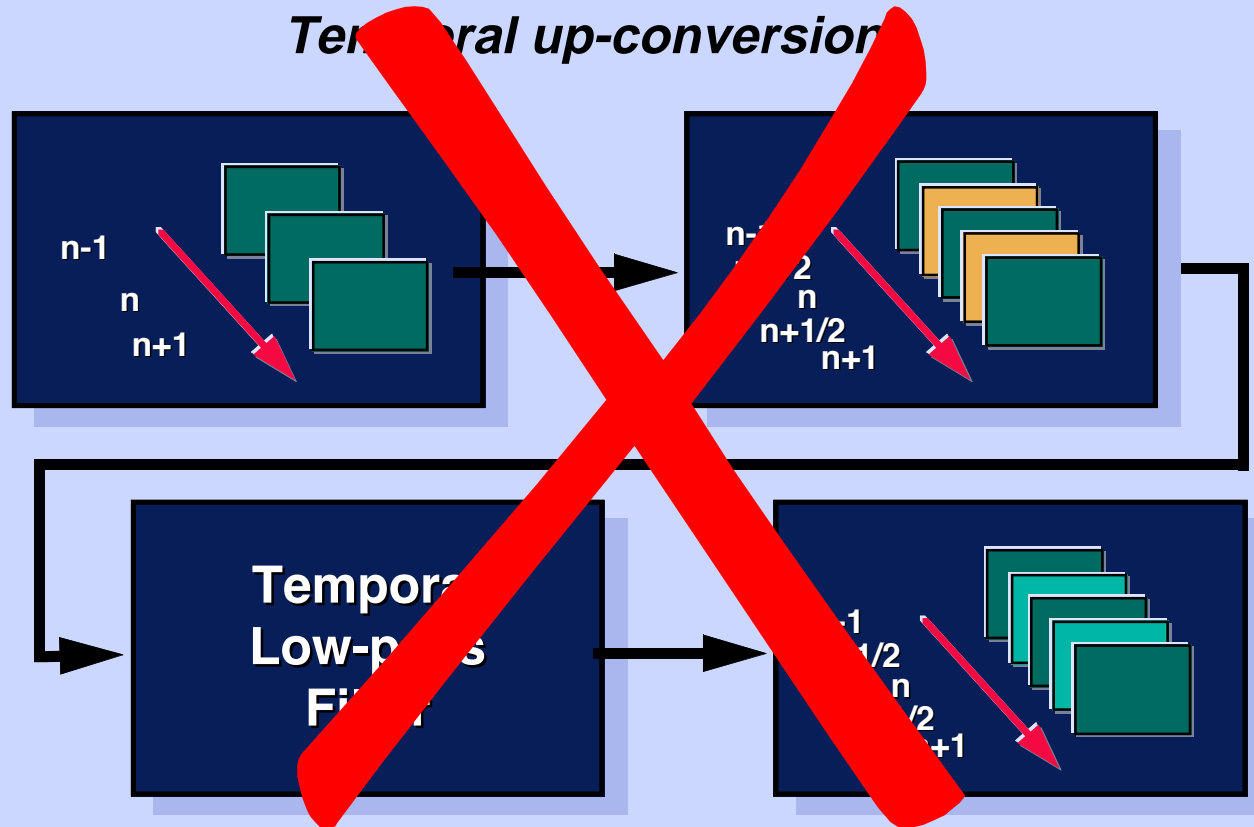
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# Introduction (4)

## *Why motion compensation?*

Linear filtering

*Temporal up-conversion*

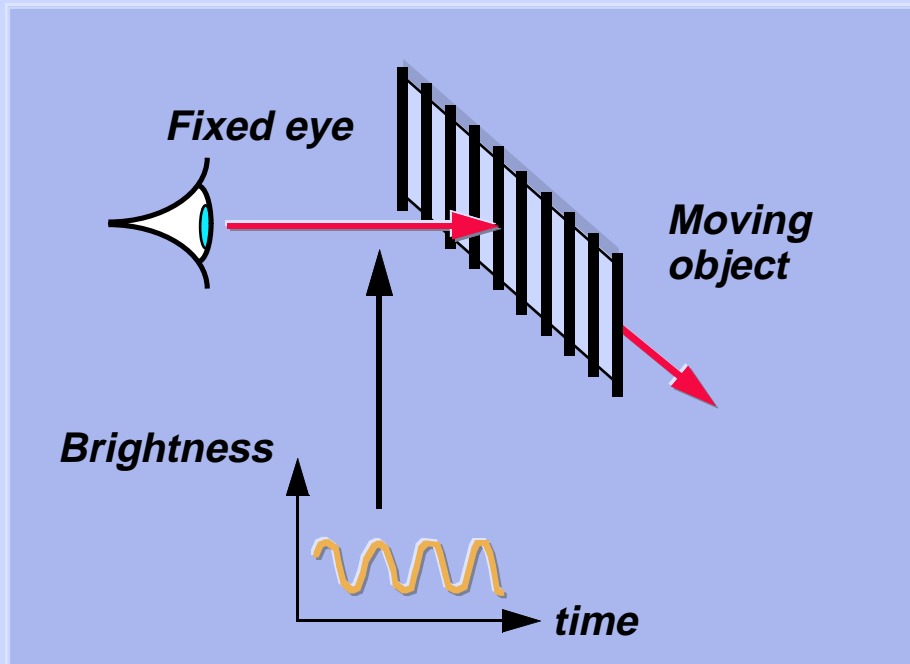


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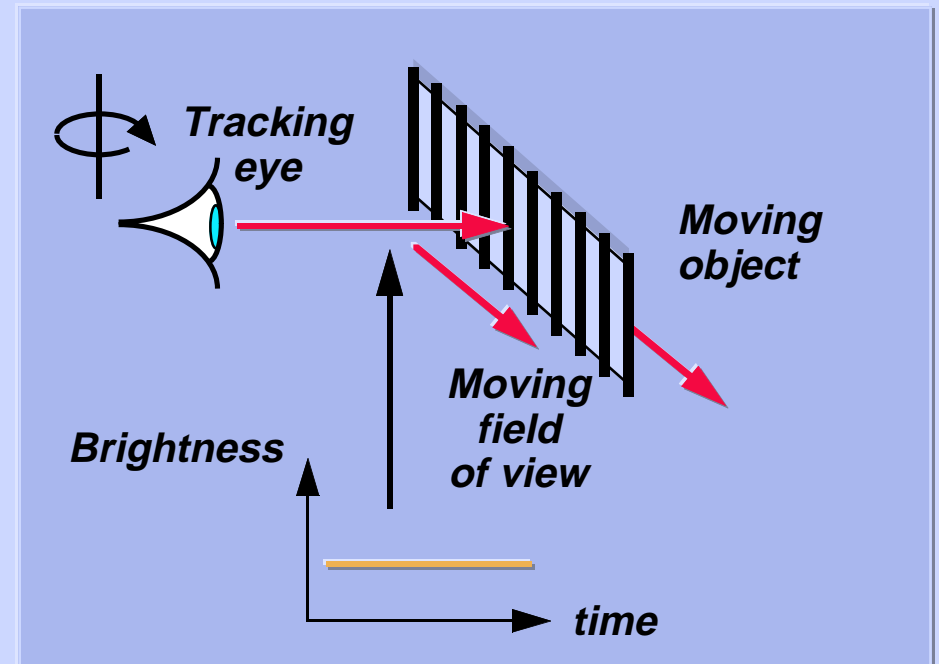
# Introduction (5)

## *Motion compensation*

### Human visual system



High temporal frequency

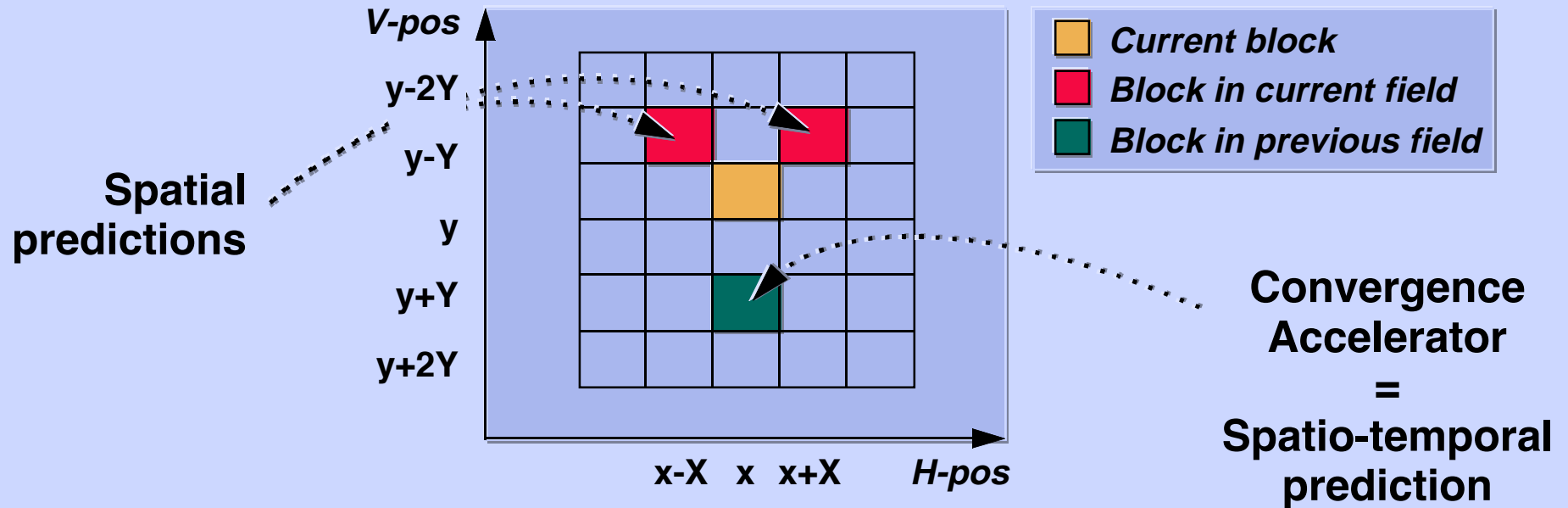


Zero temporal frequency

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# Prior Solution

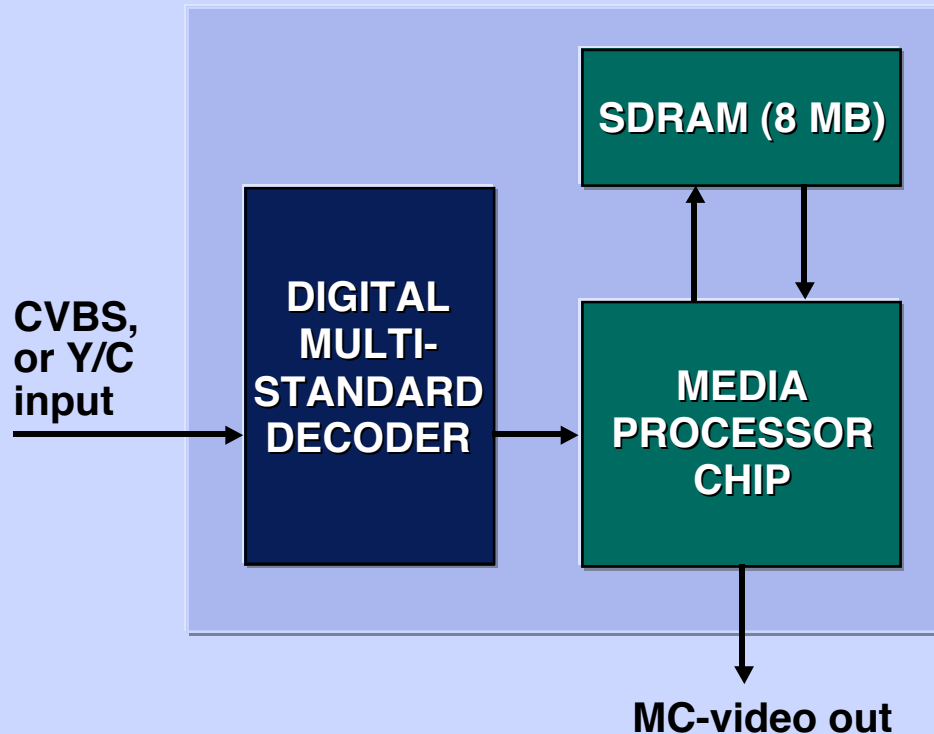
## *3D recursive search block matching*



- Implemented in hardware
- Current hardware does not support 2-3 pull-down

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# New Solution



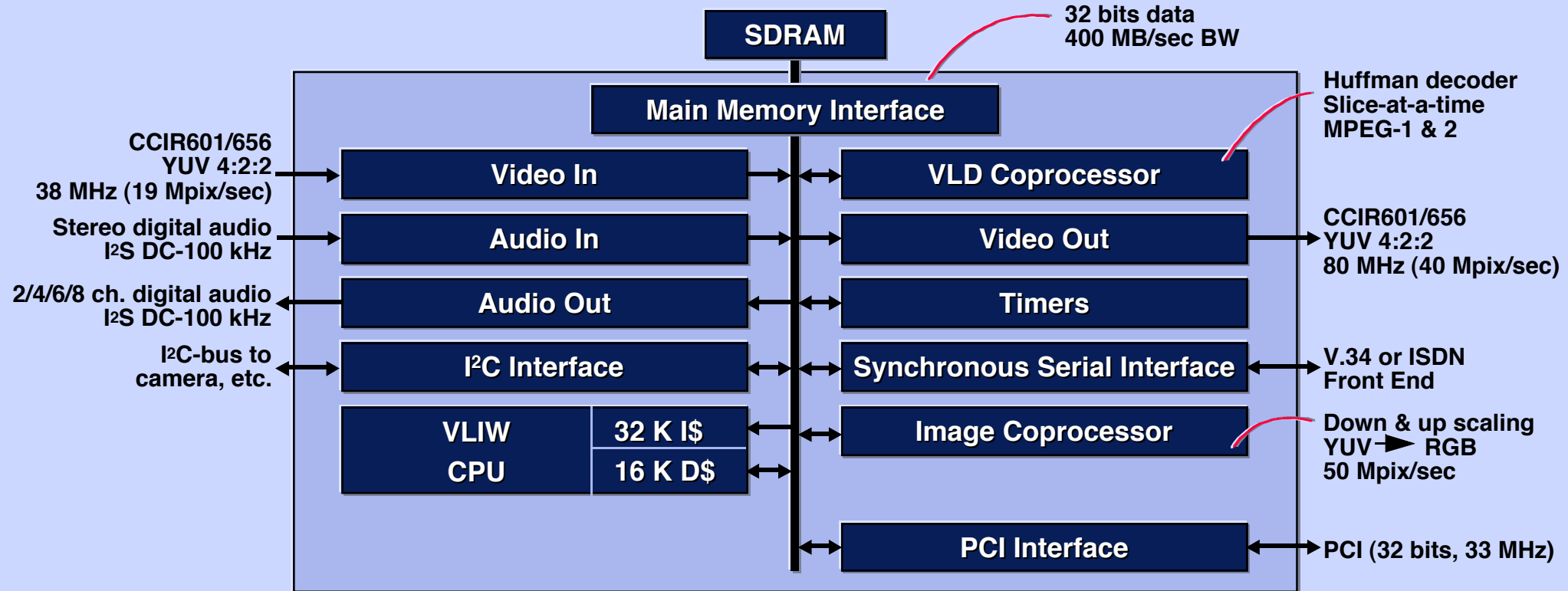
## Functionality of the media processor chip

- **Software:**
  - Object-based ME
  - Robust MC interpolation
  - Film detection (2-2 & 2-3)
  - De-interlacing
    - VT-median / weave
- **Hardware:**
  - Video I/O
  - PCI bridge

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# Programmable Device

## *Media processor chip*



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# Motion Estimation (1)

## *Object-based motion estimation*

### Block based

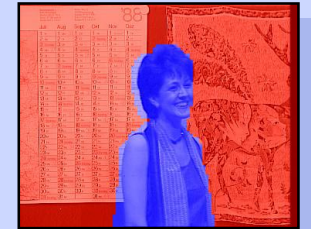


*switch  
to  
object  
based*

### Object based



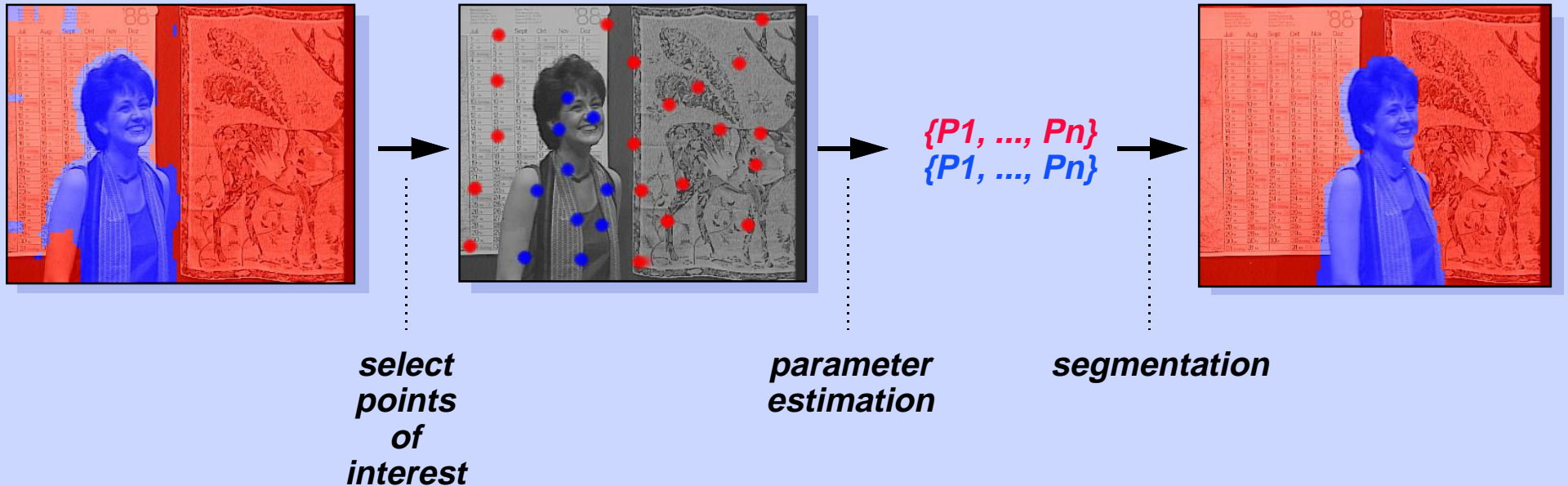
*decimate*



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# Motion Estimation (2)

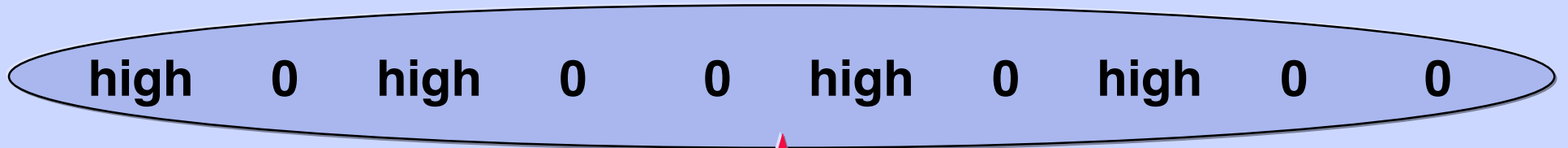
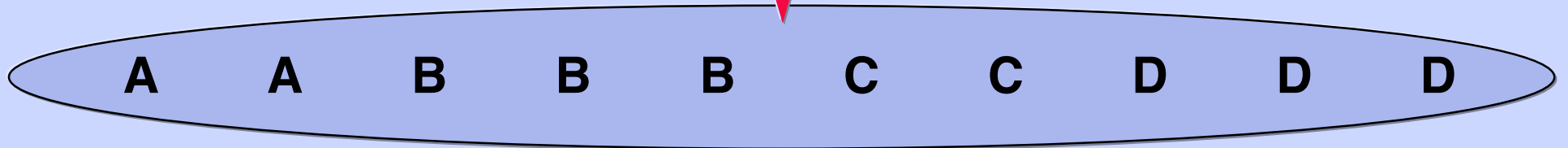
## *Object-based motion estimation*



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# Film Detection

2-3 pull-down

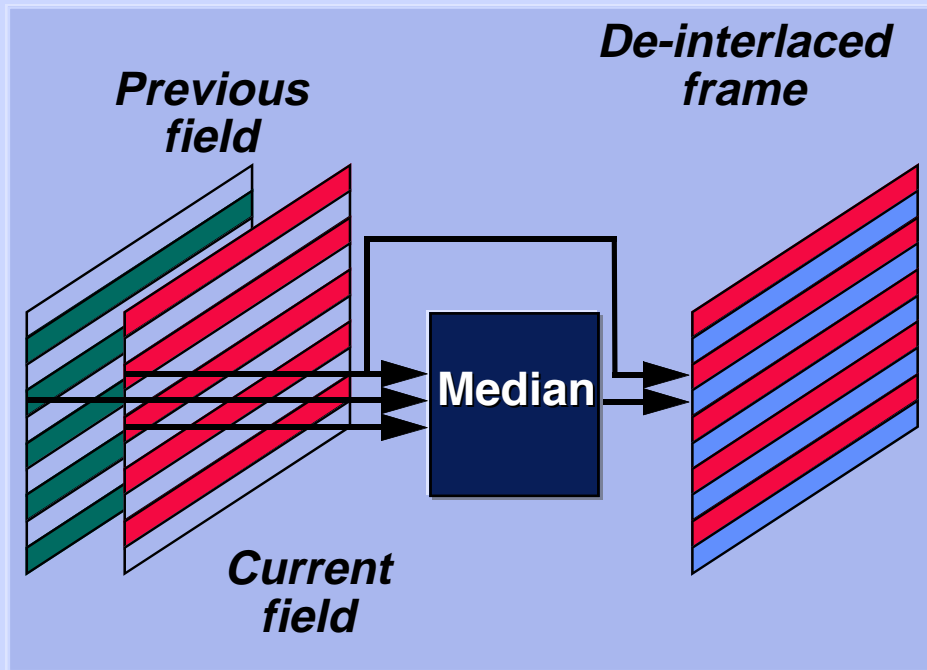


motion pattern

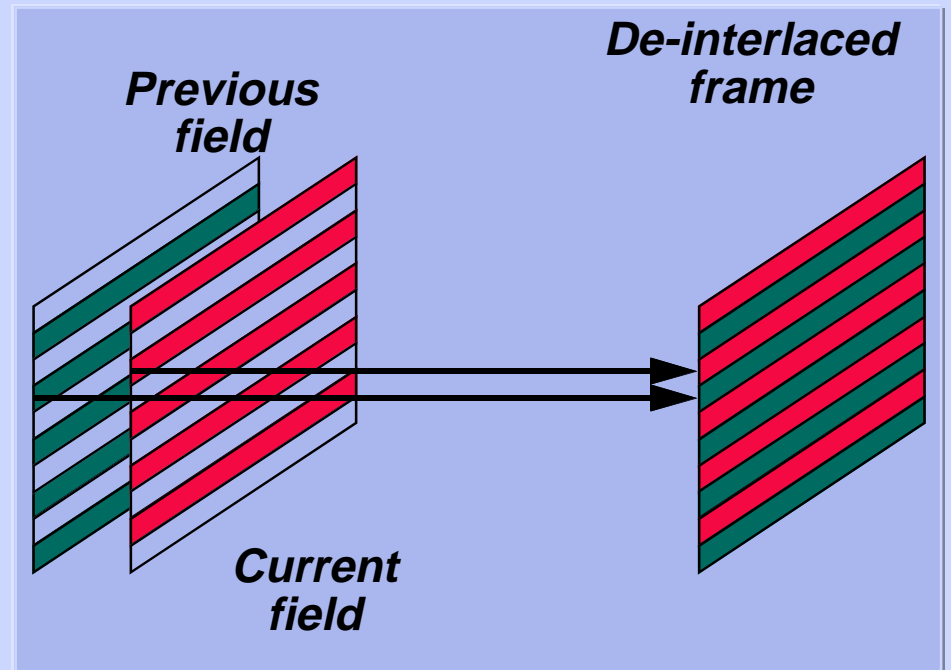
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# De-interlacing

## Video:

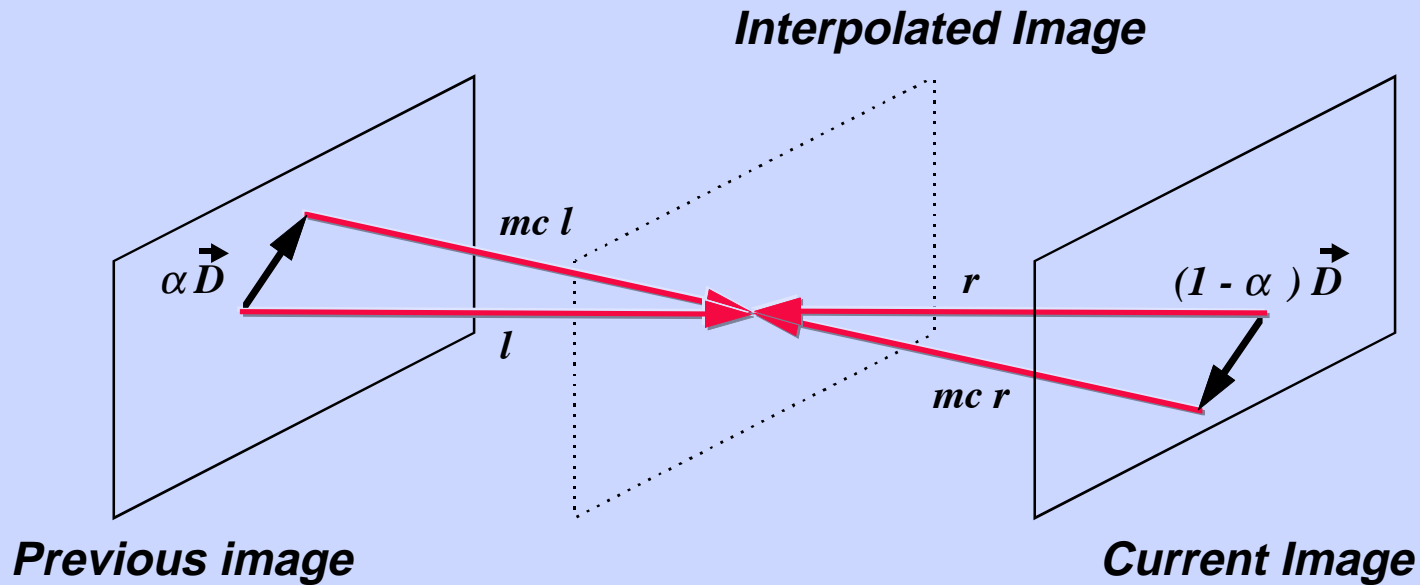


## Film:



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# Robust Up-conversion



$$av = 1/2 (l + r)$$

Output = Median ( $mcl$ ,  $mcr$ ,  $av$ )

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# Evaluation

## *Resources claimed by the software*

### CPU usage (real-time operation)<sup>1</sup>

Mode	Video (%)	2-3 movie (%)	2-2 movie (%)
Decimation	5	5	5
Parameter estimation	6	5	4
Movie detection	0	0	0
Segmentation	28	11	14
Scan conversion Y	36	40	31
Scan conversion C	9	0	0
<b>Total</b>	<b>84</b>	<b>61</b>	<b>54</b>

<sup>1</sup> Image size: CCIR601, processor: media chip @ 132 MHz

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# Conclusions

- **Motion estimation / compensation is now available at an affordable price**
- **Solutions on a programmable device are now feasible**
- **But they cannot fully compete with the performance of dedicated silicon yet**
- **However, a software implementation is very flexible and can easily be adapted to different applications such as video on PC**
- **For the first time 2-3 pull-down elimination has been realized at a consumer price level**

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