Efficient computing with MMX and Integer SSE instructions

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The samples

- Two well known techniques used in image and video coding have been implemented:
  - Image convolution
  - Motion estimation

Image convolution

The block

181	152	152
156	182	151
157	154	183

The mask

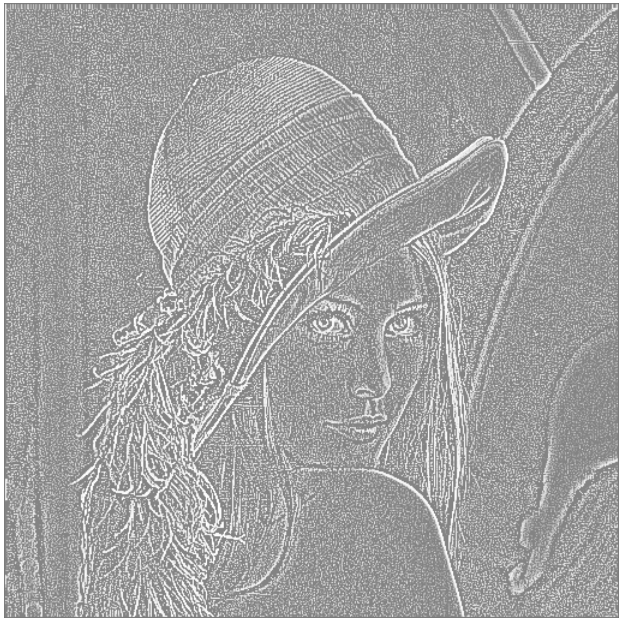
-1	-1	-1
-1	8	-1
-1	-1	-1

(181*(-1)+152*(-1)+152*(-1)+156*(-1)+182*(8)+151*(-1)+157*(-1)+154*(-1)+183*(-1))/1=170

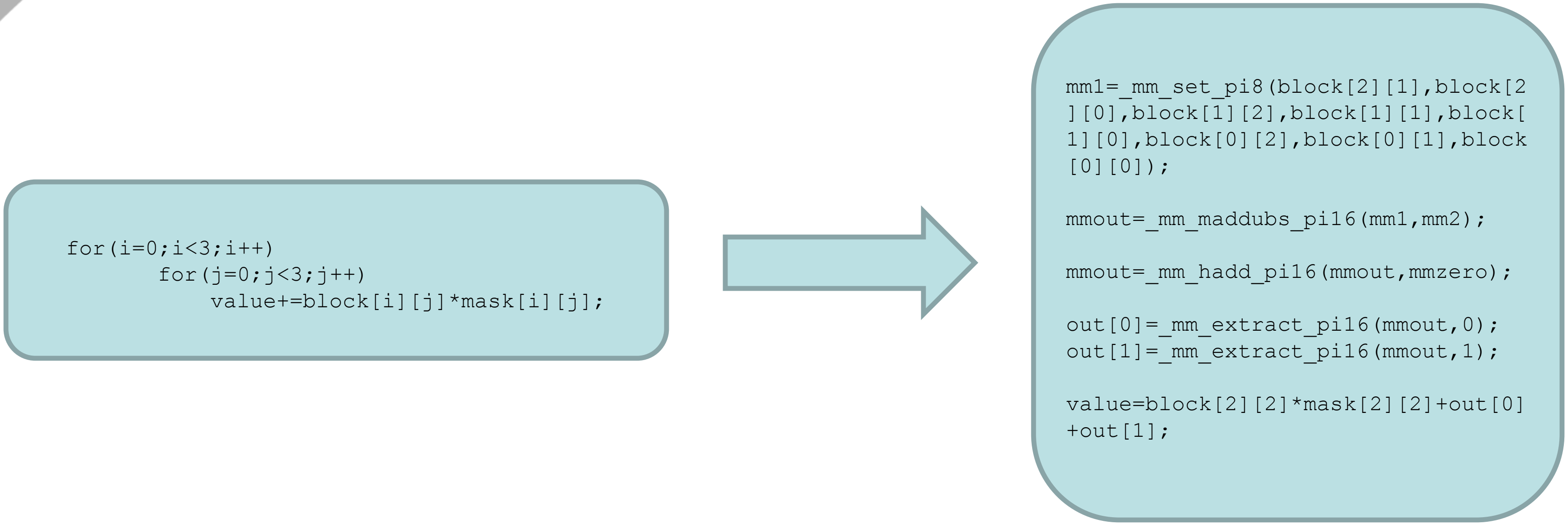
- 9 MULT
- 8 ADDS
- 1 DIV?

High-pass filter using image convolution

-1	-1	-1
-1	8	-1
-1	-1	-1



How to increase your speedup



```
for(i=0;i<3;i++)
       for(j=0;j<3;j++)
           value+=block[i][j]*mask[i][j];
```

```
mm1=_mm_set_pi8(block[2][1],block[2
][0],block[1][2],block[1][1],block[
1][0],block[0][2],block[0][1],block
[0][0]);

mmout=_mm_maddubs_pi16(mm1,mm2);

mmout=_mm_hadd_pi16(mmout,mmzero);

out[0]=_mm_extract_pi16(mmout,0);
out[1]=_mm_extract_pi16(mmout,1);

value=block[2][2]*mask[2][2]+out[0]
+out[1];
```

Speedup = 6.7

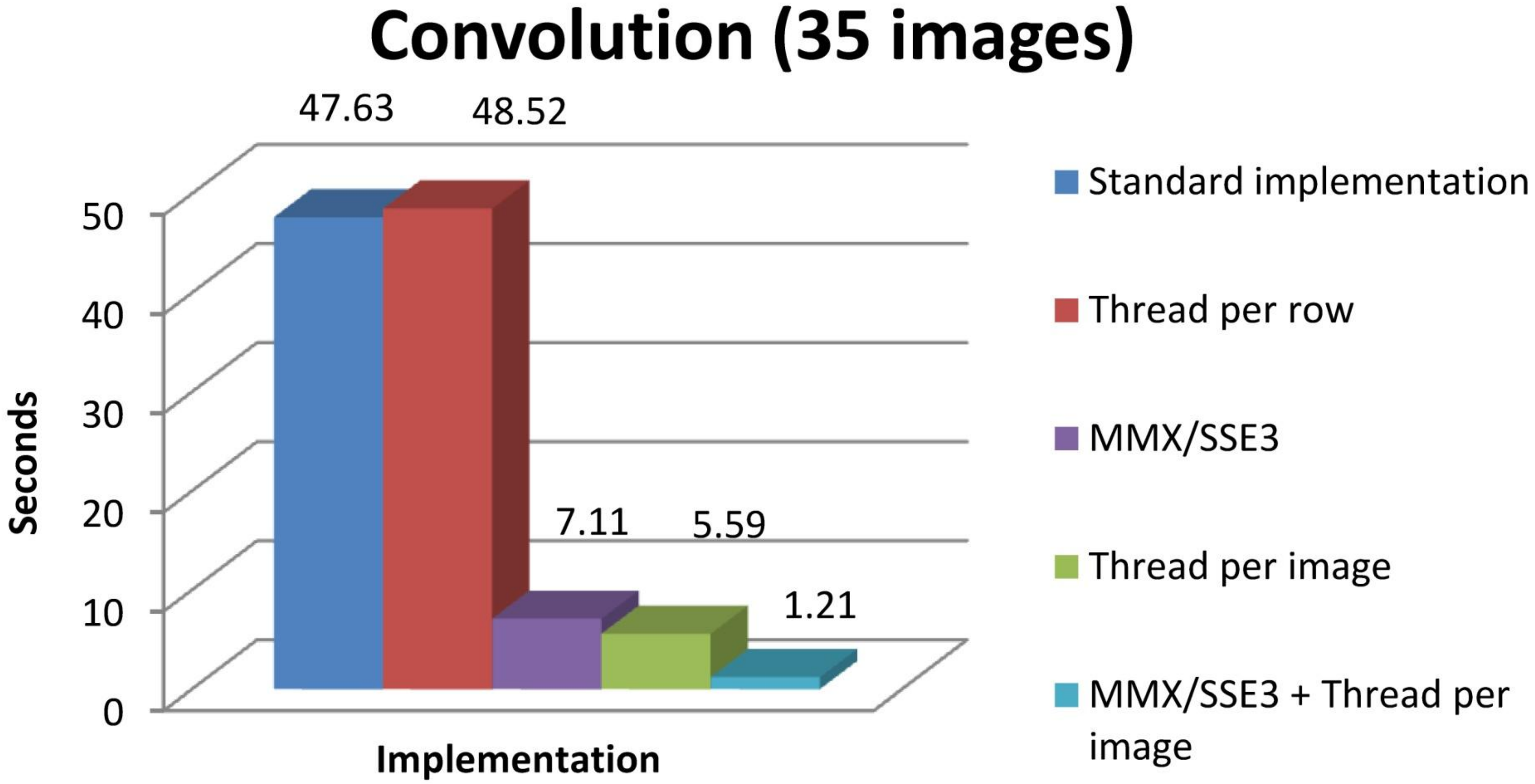
SIMD instructions

- PMADDUBSW
  - Multiplies vertically each unsigned byte of the destination operand with the corresponding signed byte of the source operand producing intermediate signed 16-bit integers. Each adjacent pair of signed words is added and the saturated result is packed to the destination operand
  - SSSE3 instruction
- PHADDW
  - Adds two adjacent 16-bit signed integers horizontally from the source and destination operands and packs the 16-bit signed results to the destination operand
  - SSSE3 instruction

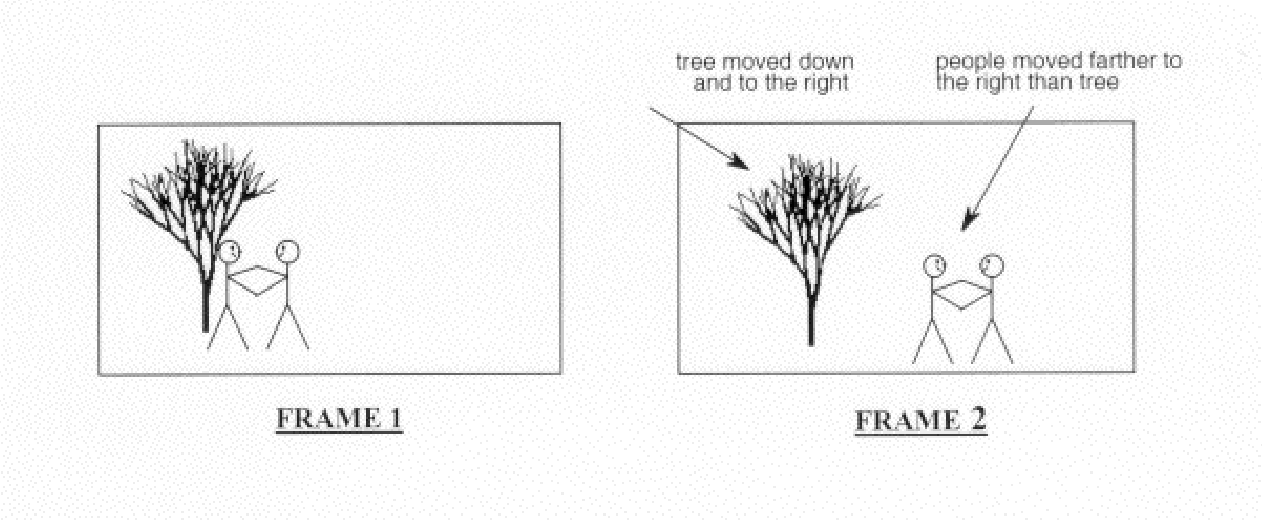
The implementations

- Several implementations:
  - Standard implementation in C (with some improvements)
  - One thread per row (pthreads)
  - One thread per image (pthreads)
  - Using MMX/SSE extensions
  - Using MMX/SSE extensions + one thread per image (pthreads)

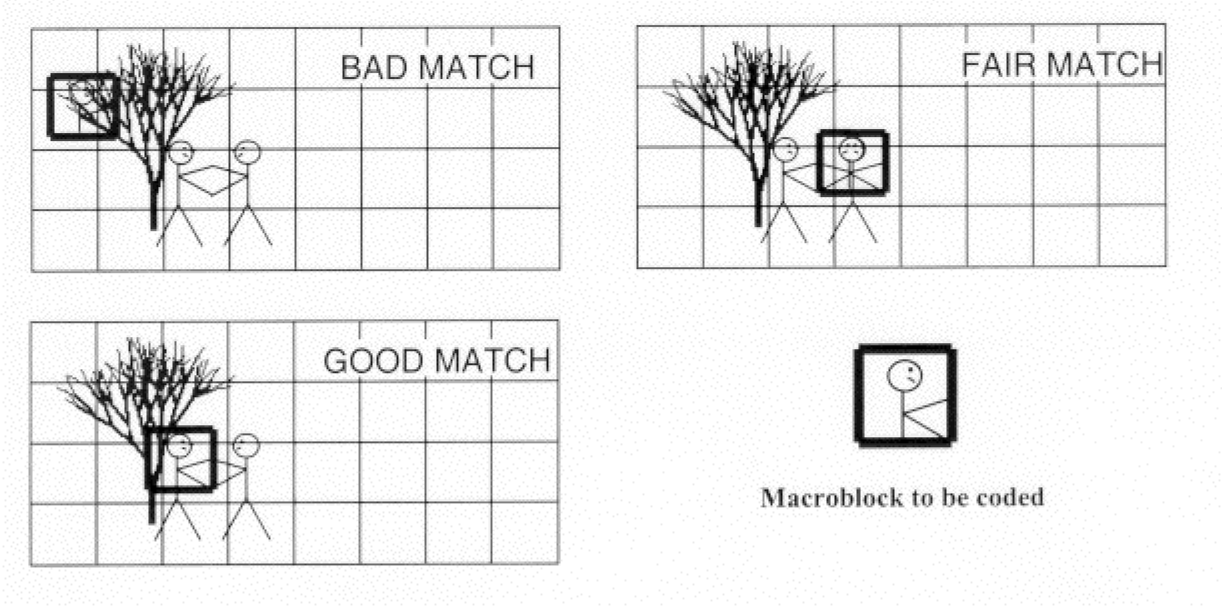
Piece of evidence



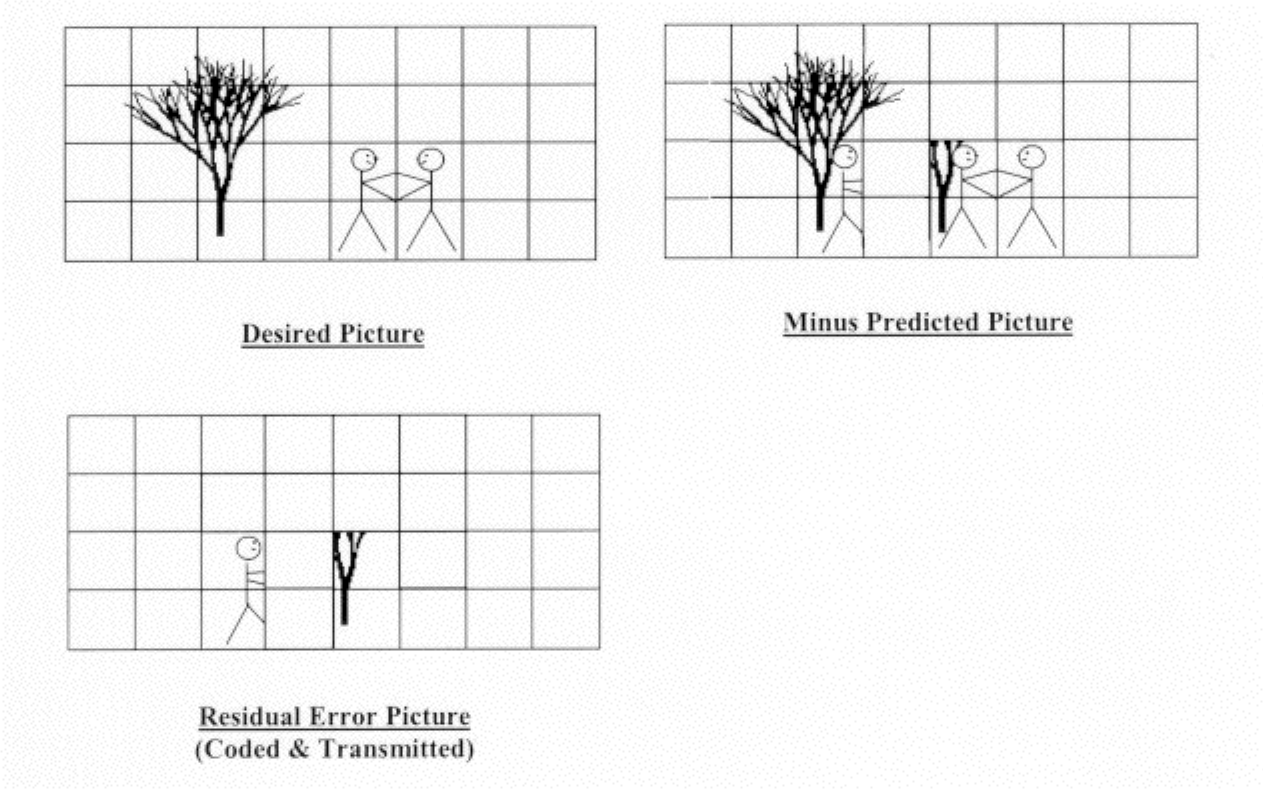
Motion estimation


tree moved down and to the right
people moved farther to the right than tree
FRAME 1
FRAME 2

Motion estimation



Motion estimation



Desired Picture

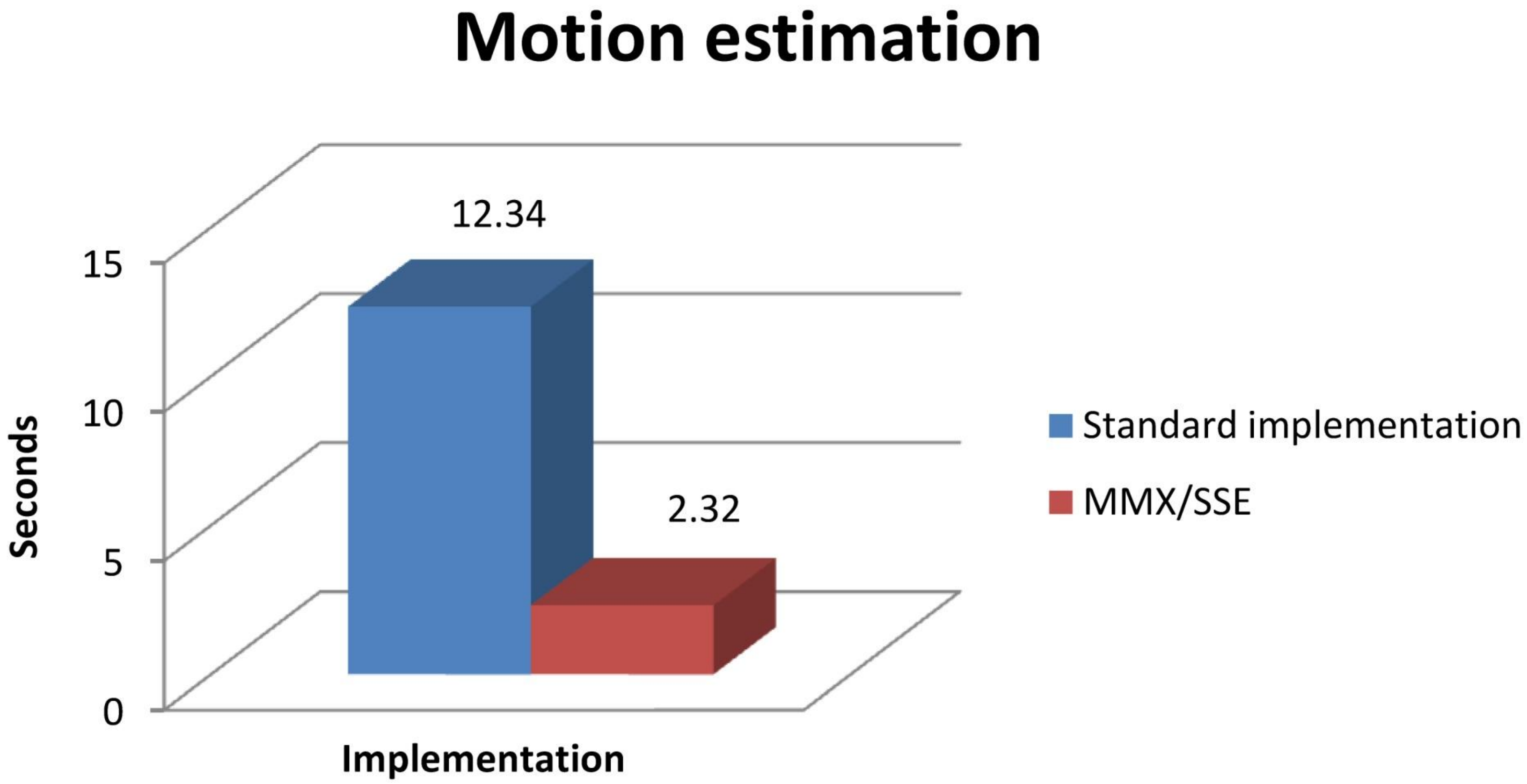
Minus Predicted Picture

Residual Error Picture
(Coded & Transmitted)

The implementations

- Two algorithms:
  - Standard implementation in C
  - Using MMX/SSE extensions

Piece of evidence



Q & A