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Real-time 3D Tracking with Camera Phones

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Augmented Reality on Mobile Phones

- Low cost, widely spread platform
  - Billions of phones deployed
  - People know how to use them
  - Strong demand from commercial side
  - Huge chance for AR!
- Target practical applications
  - Easy to use
  - 15-30 Hz overall frame rate
  - Robust tracking

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Mobile Phone Camera Tracking

Tracking for Augmented Reality always means
Pose Tracking (6DOF)

- Optical Flow
  - Very simple, but does not give a pose
- Marker Tracking
  - Works well, but limited in its applications
  - Hardly a research topic anymore
- Natural Feature Tracking
  - Currently a hot topic!

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History of AR Tracking on Phones (1)

- 2003
  - ARToolKit on PDA
  - Wagner et at.
- 2004
  - 3D Marker on Phone
  - Möhring et al.
- 2005
  - ARToolKit on Symbian
  - Henrysson et al.

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History of AR Tracking on Phones (2)

- 2005
  - Visual Codes
  - Rohs et at.

- 2006
  - Studierstube Tracker
  - Wagner et al.

- 2007
  - WikEye
  - Schöning et al.

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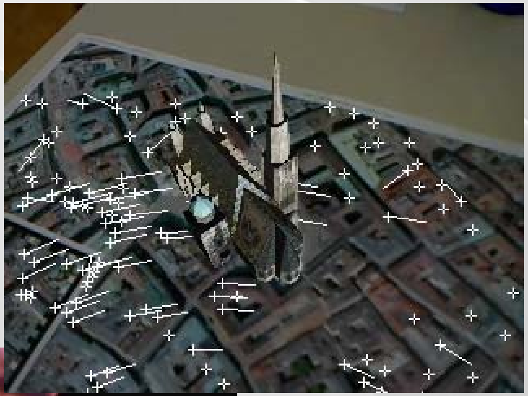
History of AR Tracking on Phones (3)

- 2008
  - Advanced Marker Tracking
  - Wagner et al.



- 2008
  - Natural Feature Tracking
  - Wagner et al.

- 2009
  - High speed Natural Feature Tracking

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CPU/Memory Limitations of Mobile Phones

- Small memory
  - Even though phones today have 64-128MB RAM consider **2-5 Megabytes** as maximum
- Weak processing power
  - **200-600 MHz, Single core**
  - Typically **no FPU** (floating point ~40x slower than integer)
  - Slow memory access, small caches

→ Code optimized for phones runs **5-10x slower** on a high-end phone than on an average PC (2GHz, single core)

→ Not going to change quickly due to battery power

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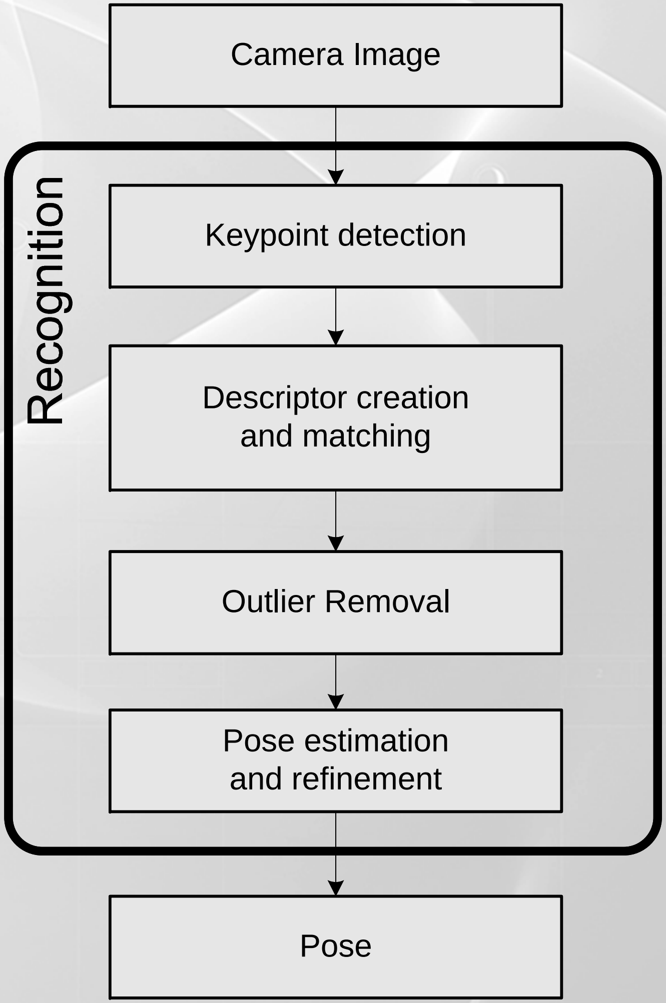
Tracking by Detection

- This is what most „trackers“ do…
- Targets are detected every frame
- Popular because tracking and detection are solved simultanously



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Natural Feature Tracking by Detection

SIFT

- State of the art for object recognition
- Known to be slow
(best implementation for phones is ~10-100x **too slow** for real-time use)
- Typically used off-line

Ferns

- State of the art for fast pose tracking
- Known to be memory intensive
(requires ~10x **too much memory** for phones)
- Long training phase

SIFT: [Lowe, 2004]   Ferns: [Ozuysal, 2007]

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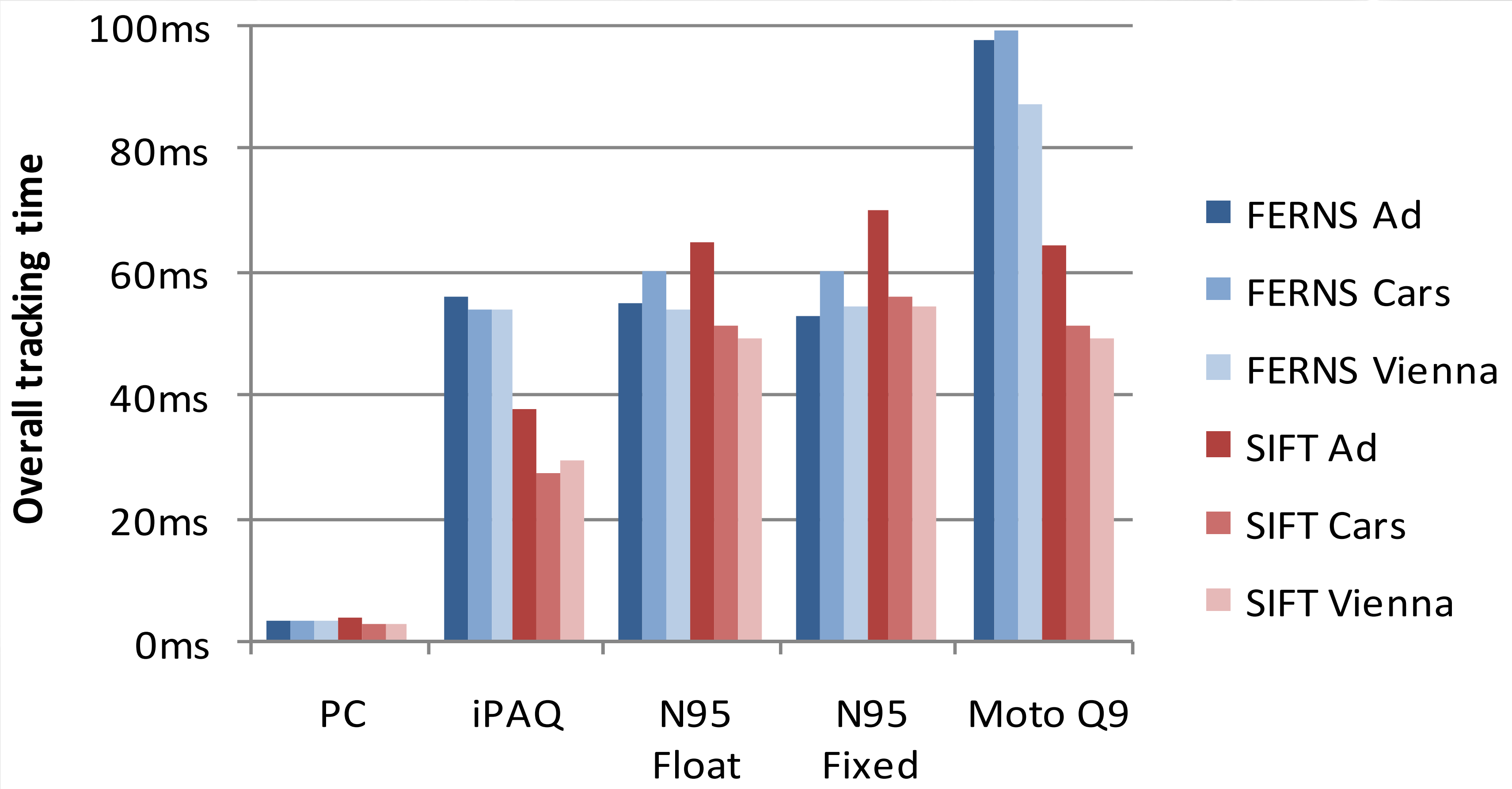
Performance of SIFT and Ferns modified for mobile phone tracking



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NFT with SIFT on a Mobile Phone

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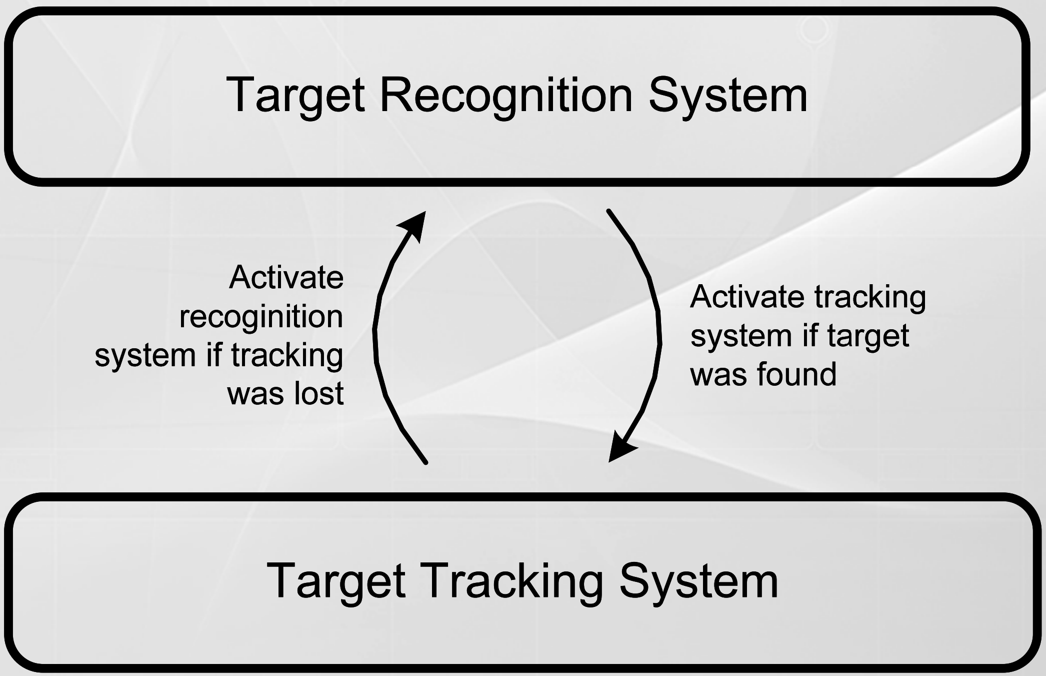
Doing it better:
Dedicated Detection and Tracking



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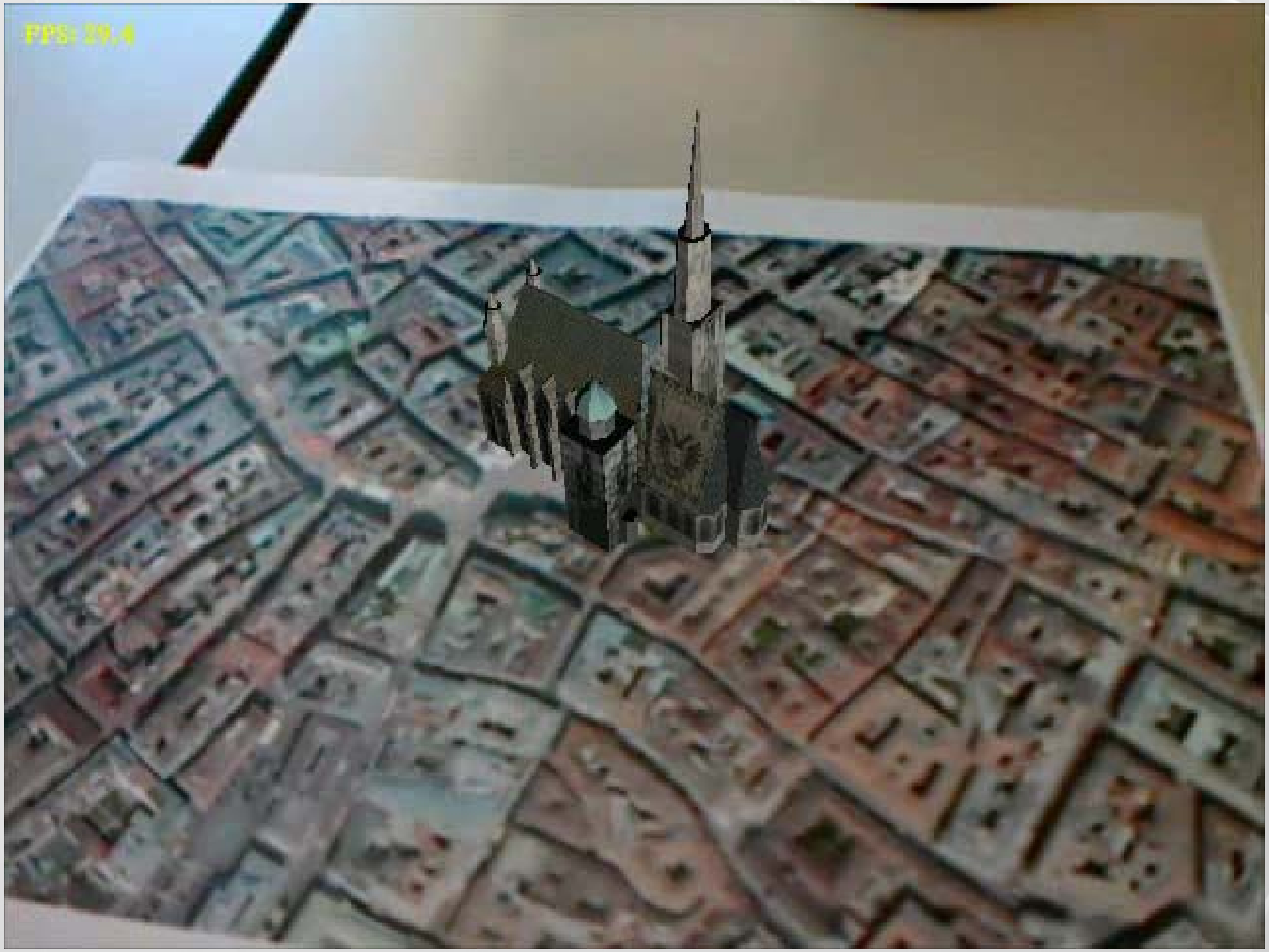
Detection and Tracking



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High Speed Tracking on the Mobile Phone

ROBUST HIGH SPEED
NATURAL FEATURE TRACKING

TRACKING OF MULTIPLE TARGETS

MEMORY REQUIREMENTS:
~300KB/TARGET

DEVICE: ASUS P552W, 624MHz
RENDERING: OPENGL ES 1.1
CAMERA: 320x240, 20Hz

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Workflow of our Tracker

- During startup: find features in a reference image
- At runtime:
- Take previous pose and apply motion model
  - Get estimate for what we are looking for
- Create affine warped patches of reference features
  - Closely resemble how the feature should look in the camera image
- Project patches into camera image and use normalized cross correlation (NCC) to match

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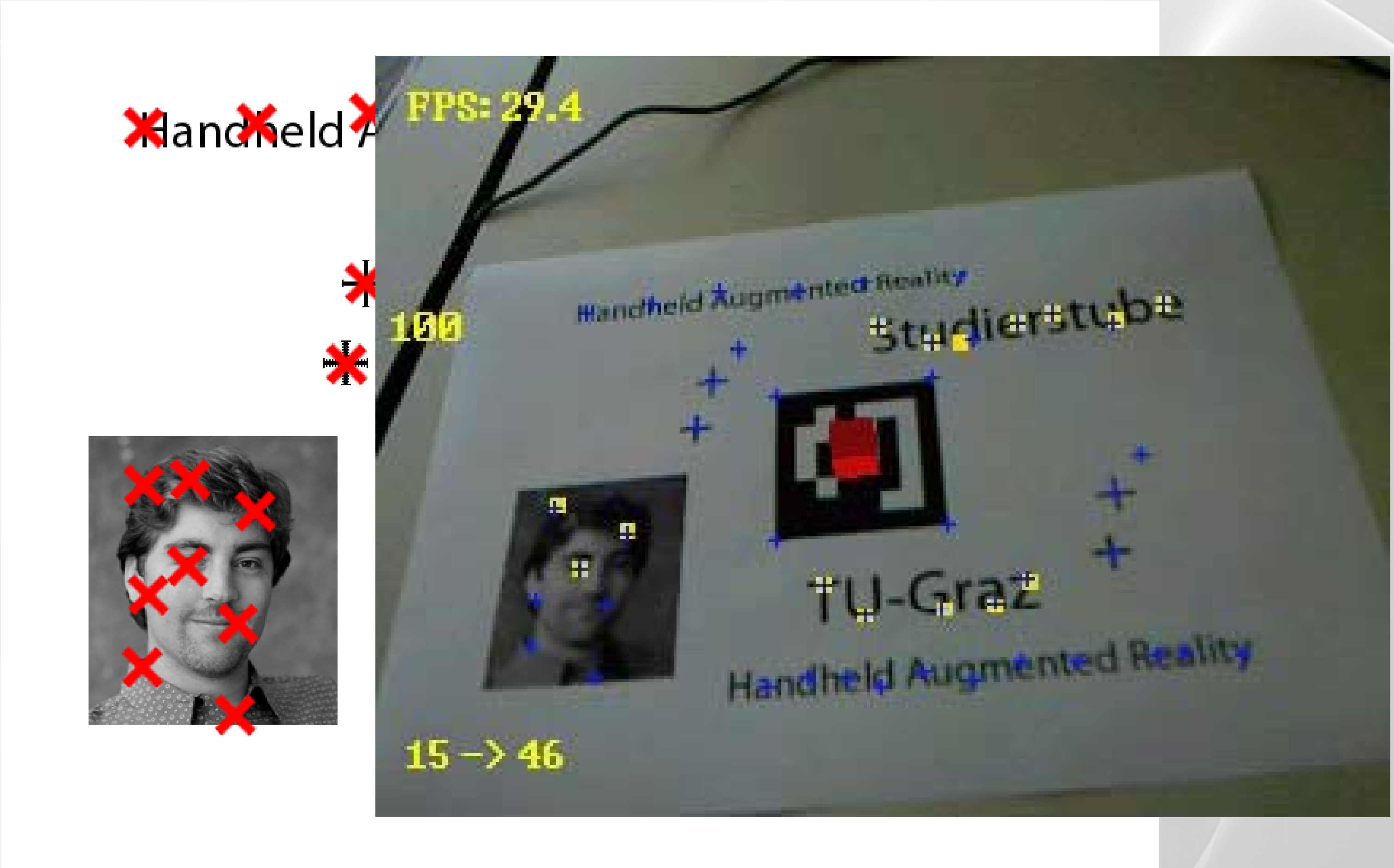
PatchTracker in Action (1)



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PatchTracker in Action (2)

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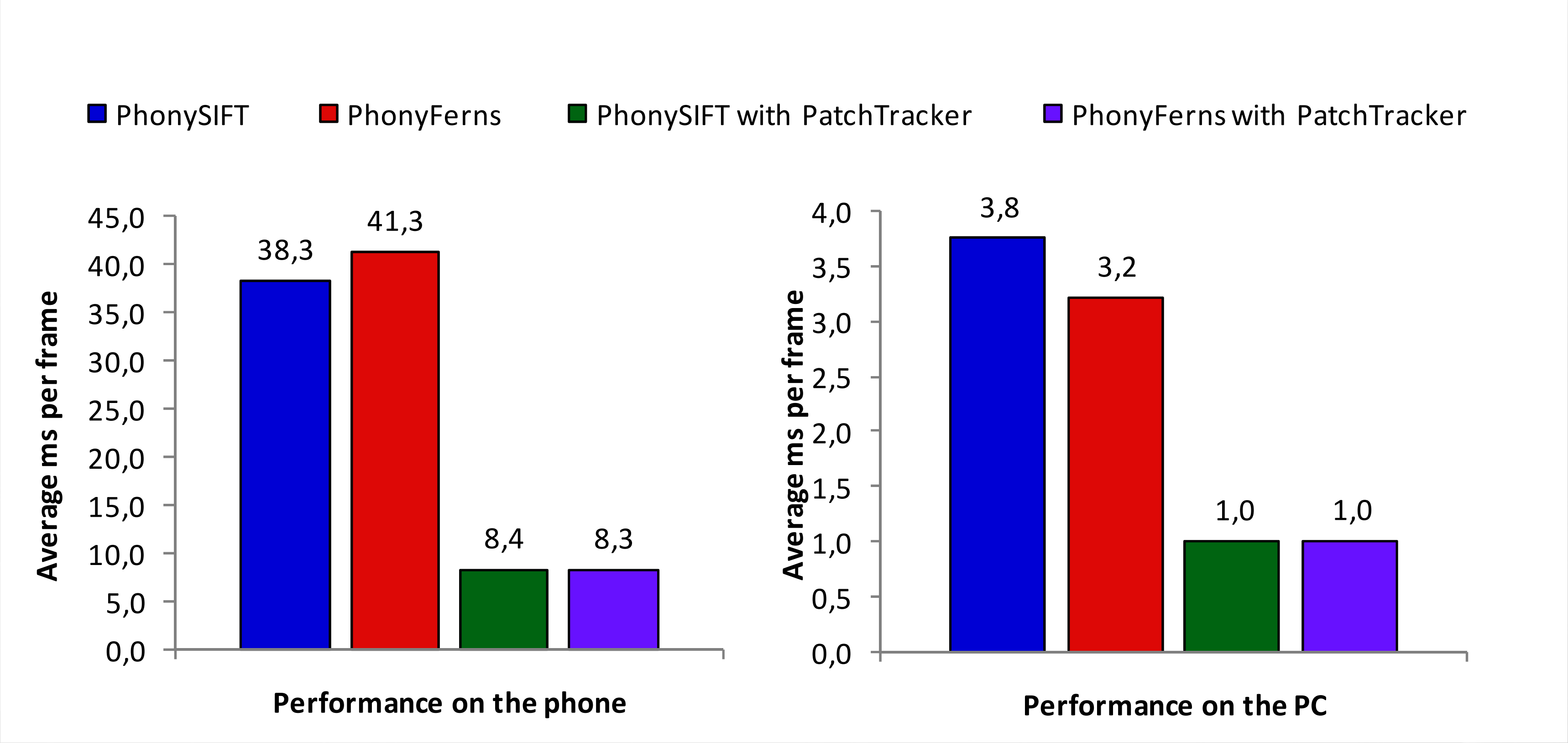
How fast is it?



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Orthogonal Strengths and Weaknesses

	SIFT/Ferns	PatchTracker
Recognize many targets	☑	☒
Detect target	☑	☒
Initialize tracking	☑	☒
Speed	☒	☑
Robust to blur	☒	☑
Robust to tilt	☒	☑
Robust to lighting changes	☐	☑

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More Results… (1)

Mobile Phone
Augmented Reality

at
30 Frames per Second
using
Natural Feature Tracking

(all processing and rendering done in software)

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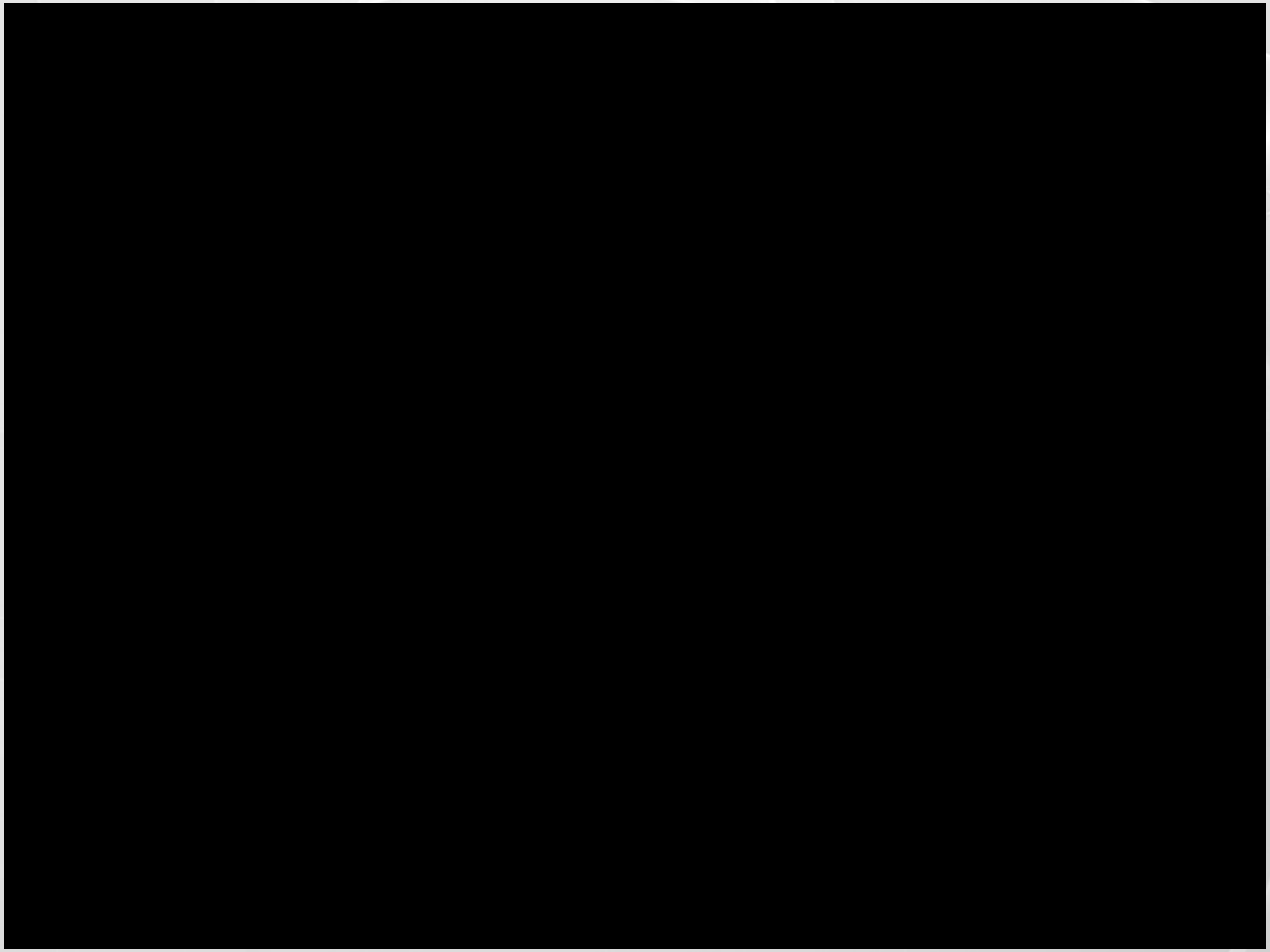
More Results… (2)



Created by the group of Blair MacIntyre and others…

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Conclusions & Future Work

- NFT sometimes more robust than markers
  - Bad lighting (blur)
  - Occlusions
- Many open issues
  - Non-planar targets
  - Large targets (rooms, building, cities)
  - Automatic target acquisition (SLAM)
  - GPU implementations

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Thank you for listening…