

# Performance of a Smartphone-based Star Tracker



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iCubeSat 2015  
Imperial College London, UK

# Research details

Research topic

Development and evaluation of a miniature Star Tracker for nanosatellite application

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Started

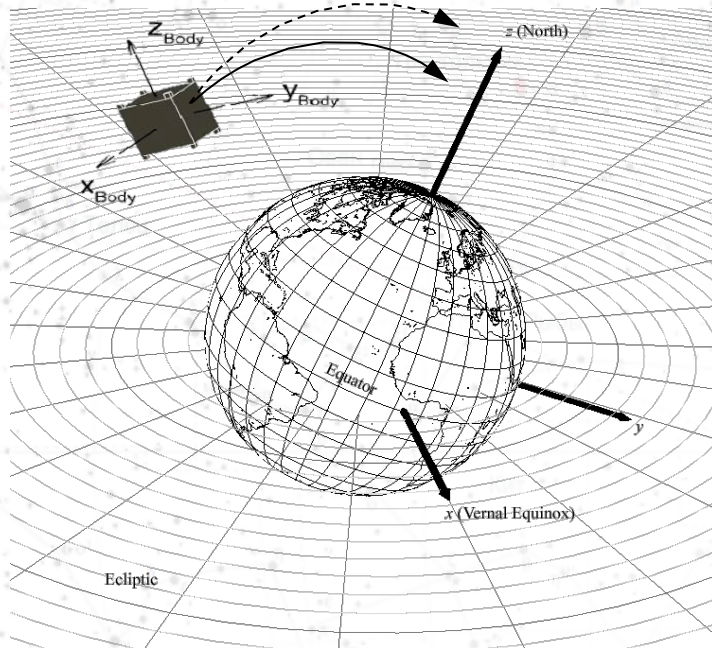
November 2013

Sponsored by

Van Allen Foundation

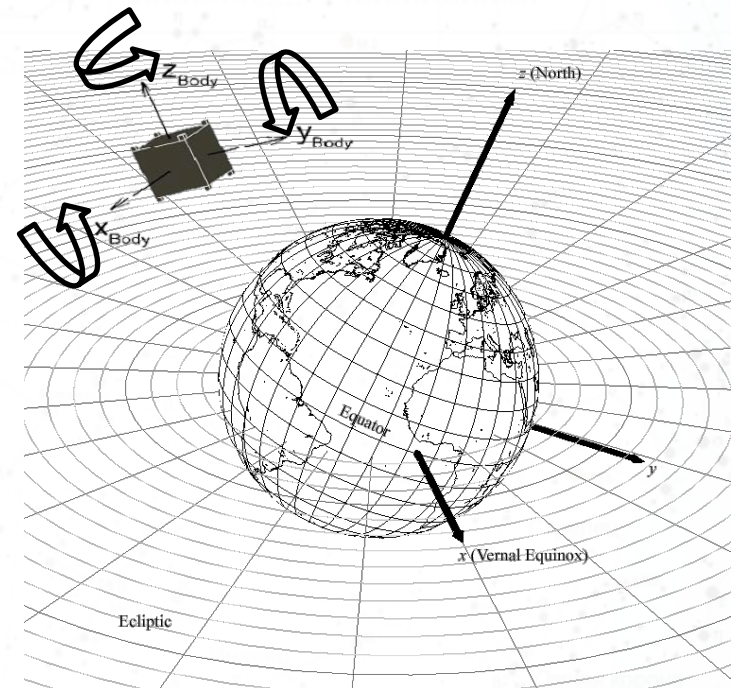


# Orbit and attitude control of a SC



## Orbit control

- Altitude
- Inclination
- Orbit shape and phase



## Attitude control

- 3-axis stabilization modes
- Transitions between modes
- Custom 3-axis rotations





# Star Tracker as an attitude sensor

Other sources for information about attitude:

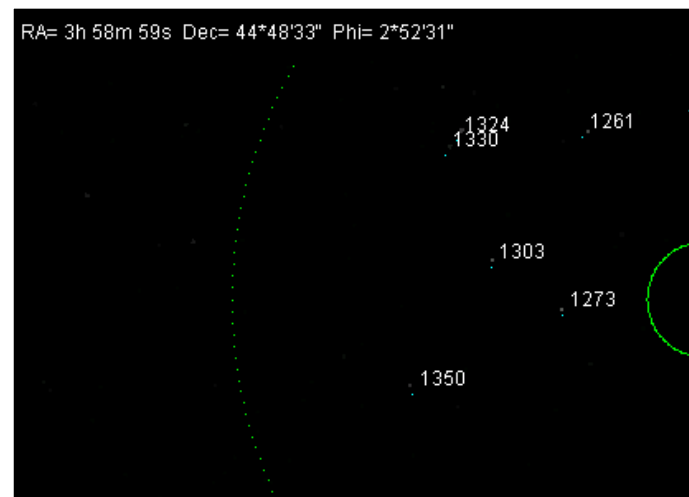
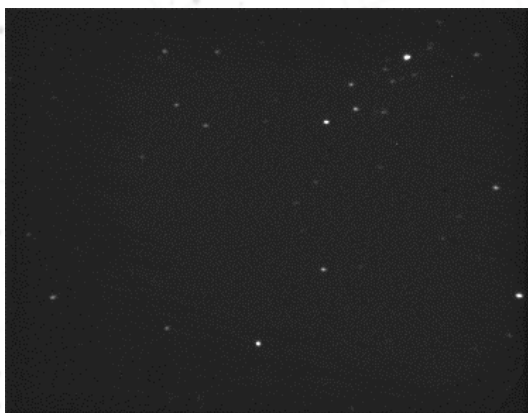
- Sun sensor
- Magnetometer (Earth's magnetic field)
- Earth's IR sensor

# Star Tracker principle of operation

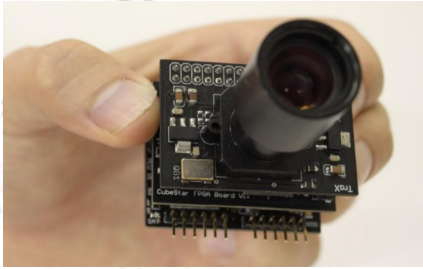


## Modes:

- Tracking
- Lost-in-space
- High angular velocity



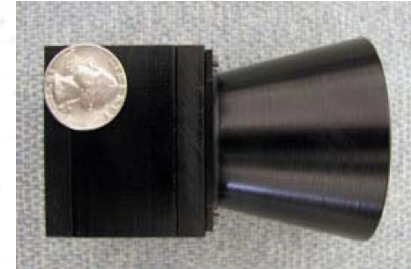
# Miniature Star Trackers



CubeStar



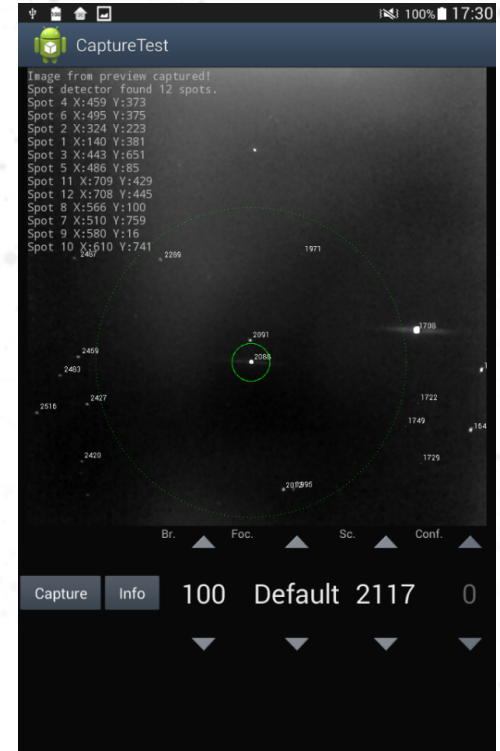
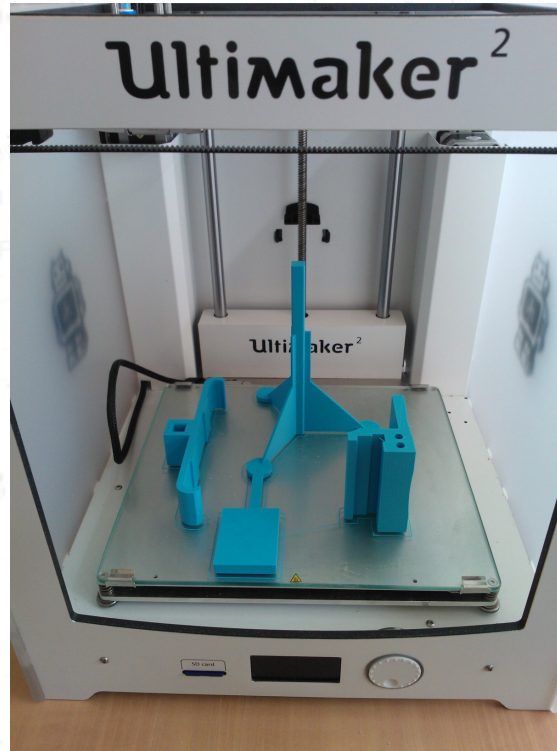
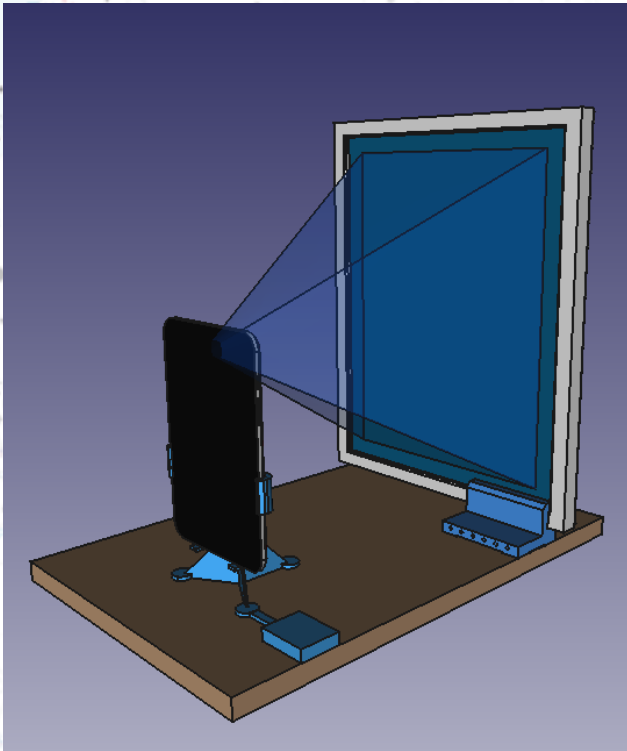
STELLA



AeroAstro

	Accuracy	Initial acquisition time	Update rate	Size	Weight w/o baffle	Power consumption	Tracking mode	Angular velocity mode
Altair HB+	10"	n/a	1 Hz	L	≈ 2.1 kg	12 W	Yes	No
SED26	3"	n/a	10 Hz	L	3.1 kg	9.0 W	Yes	Yes
Terma	1"	3 (10) s	4 Hz	L	≈ 2 kg	7.0 W	Yes	No
Astrol 15/17	3"	≈ 3 s	22 Hz	M	0.7 kg	5 W	Yes	No
AeroAstro	70"	n/a	2 Hz	S	0.375 kg	2.0 W	Yes	Yes
BCT	6"	2 s	5 Hz	S	0.350 kg	0.5 W	Yes	No
STELLA	36"	0.25 s	4 Hz	S	0.120 kg	0.2 W	No	No
<NAME>	5-10"	< 1 s	5-20 Hz	XS	≈ 0.1 kg	1-4 W	Yes	Yes

# Demonstration setup

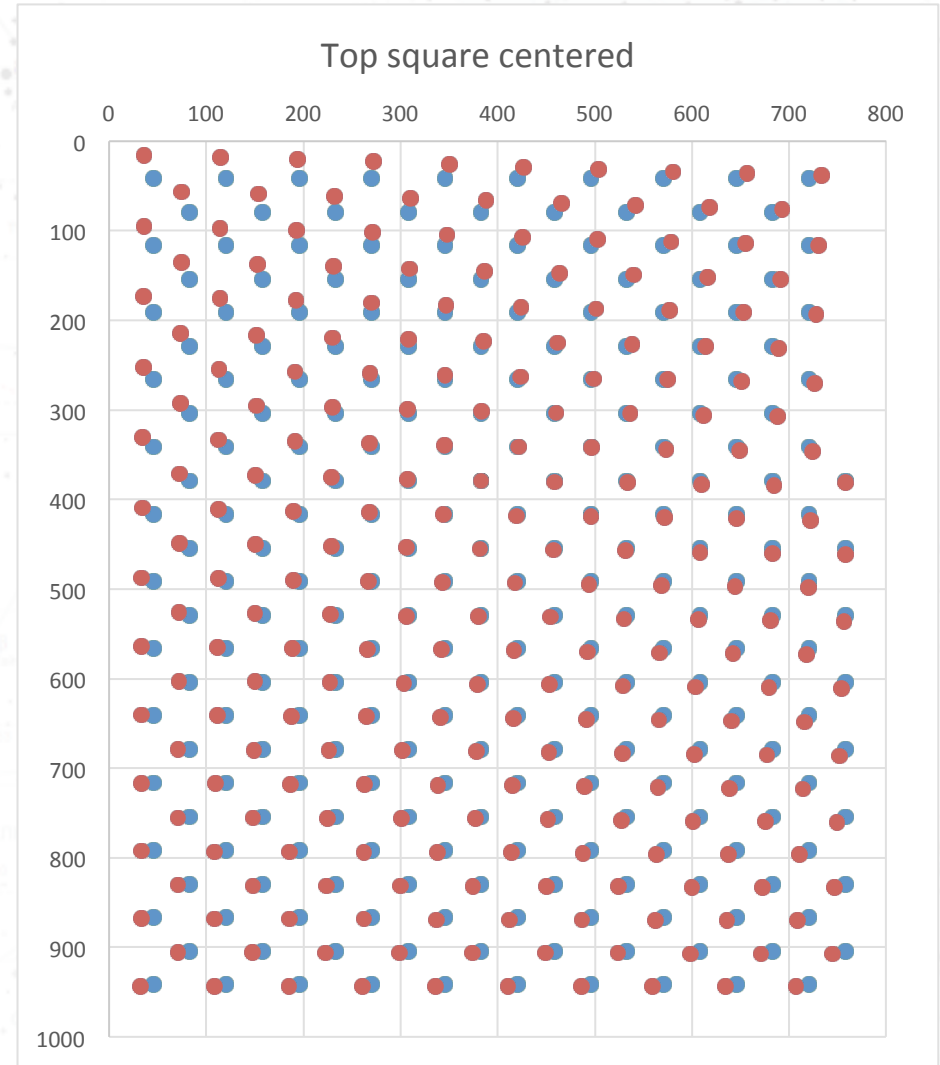




# Low-end camera problems

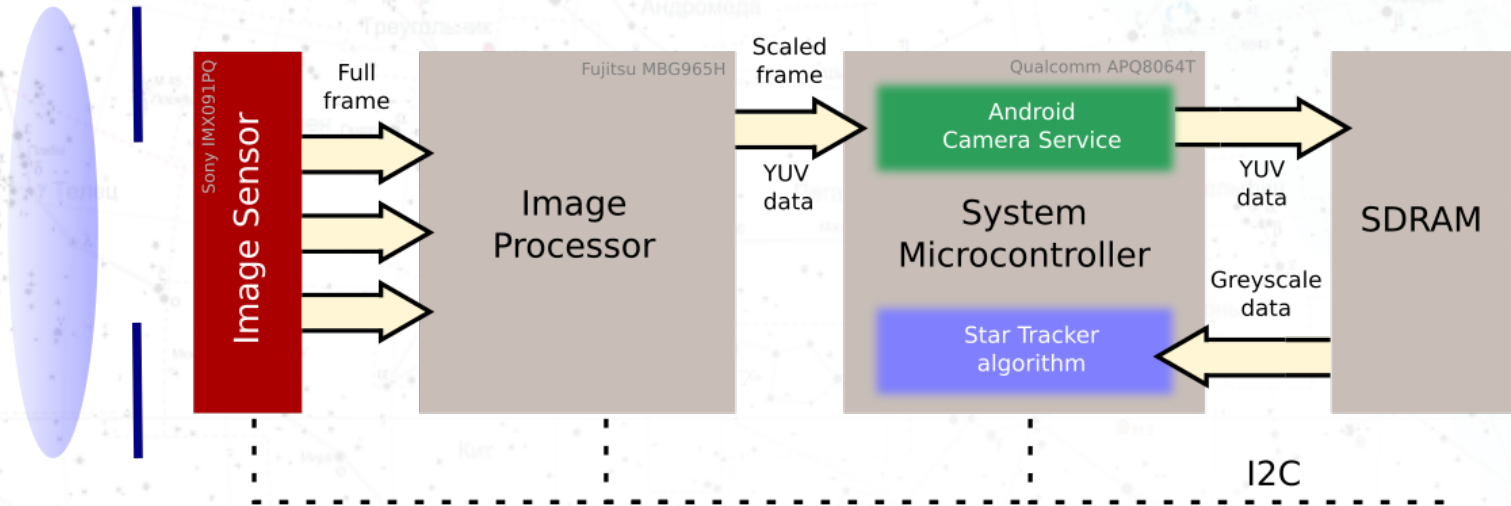


1. Poor light sensitivity
  - Aperture size
  - Color filters
  - Pixel wiring
  - Amplifier noise
2. Low frame rate
3. Optical distortions and manufacturing defects





# Smartphone hardware



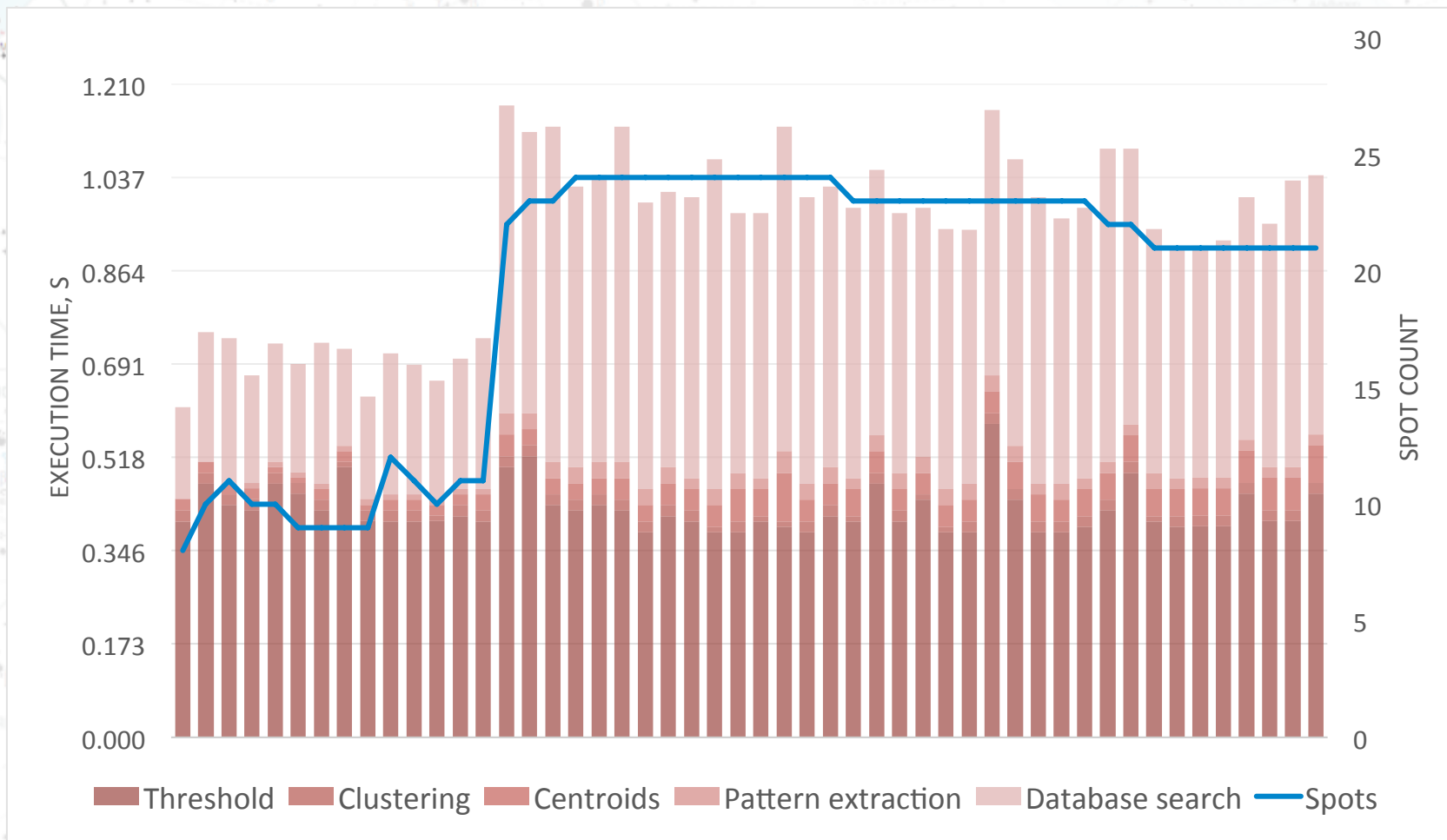
FOV  
Focus length  
Aperture  
Sensor  
Dedicated ISP

69°  
4.2 mm  
 $f/2.2$   
Sony IMX091PQ  
Fujitsu M10MO



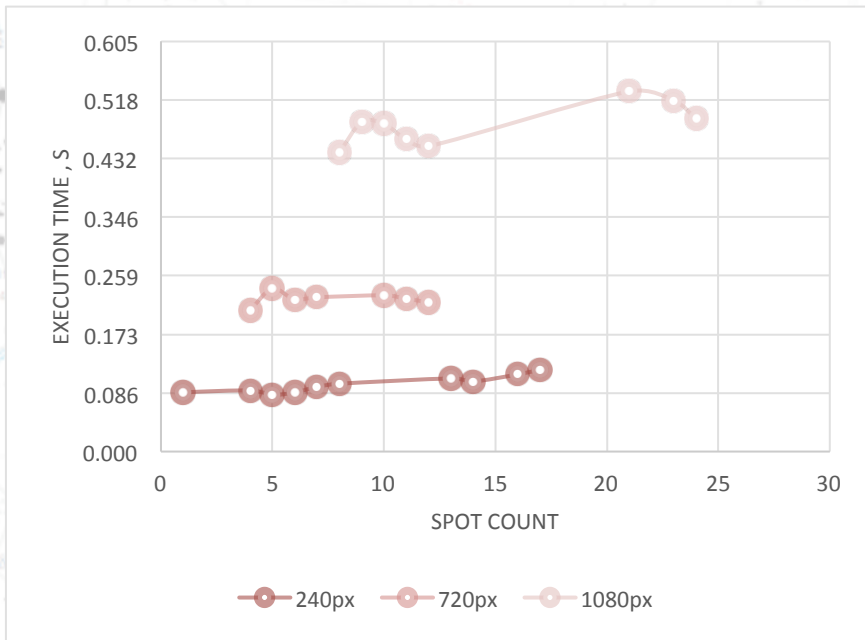
Cores 4 x Krait300  
Clock up to 1.9 GHz

# Second round of tests

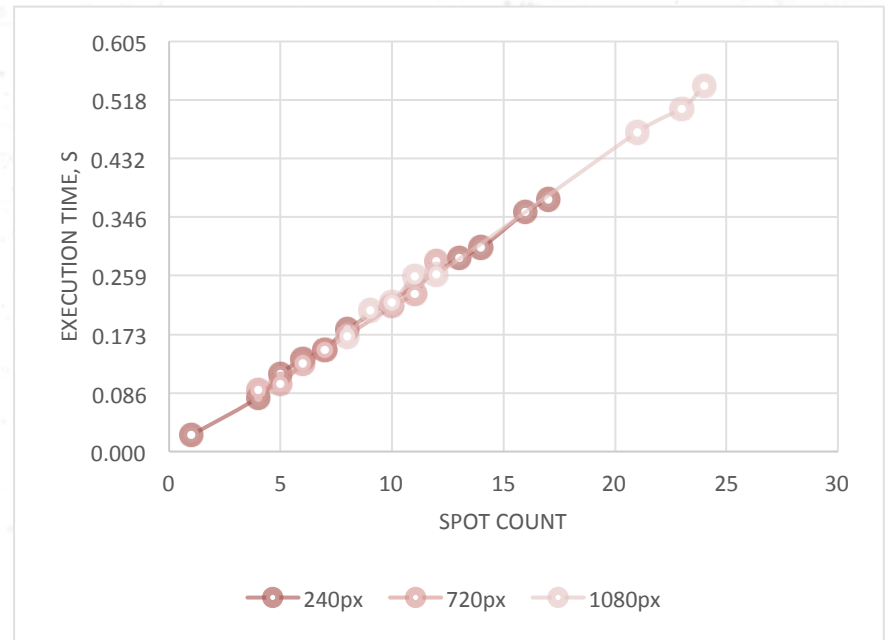


# Influence of pixel and spot count

*Extract step*

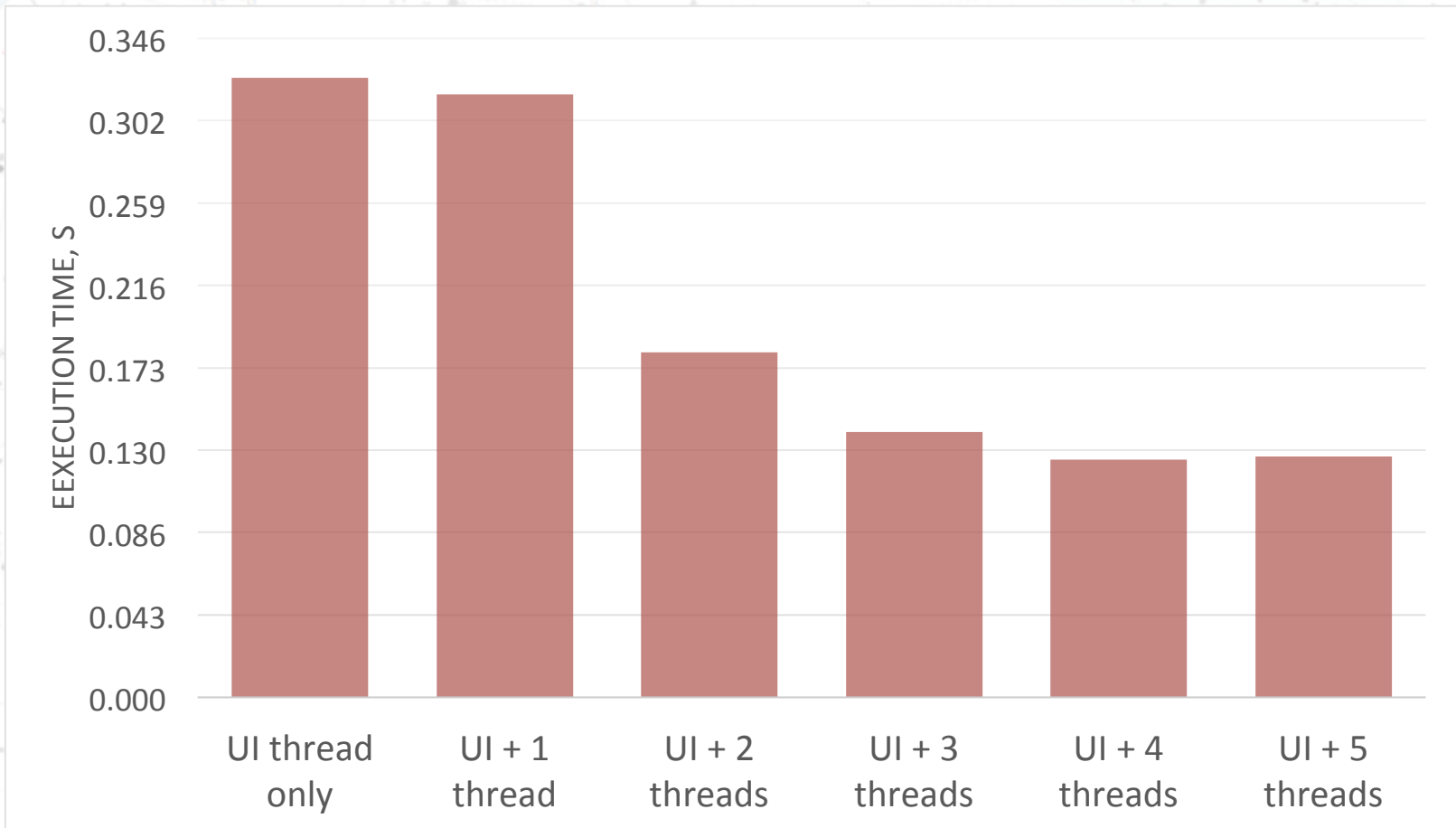


*Match step*





# Multi-threaded implementation



# Conclusions



Star tracker algorithm may be ported to an Android smartphone with a camera



Smartphone-based ST has limited capabilities when used with real night sky



Smartphone-based star tracker could be used in hardware-in-the-loop set up with sky simulation



Hardware solutions used in modern smartphones may give a good example of hardware architecture

A detailed star chart background featuring various constellations and stars. Constellations like Cassiopeia, Andromeda, and Perseus are visible, along with numerous individual stars and their designations. The chart is rendered in a light, semi-transparent style, allowing the text to be clearly legible.

# Future work

## Future work:

- star tracker validation (paper)
- star tracker algorithm (paper)
- tests with R3a ADCS (hardware-in-the-loop)
- special cases of hardware architecture



A detailed background constellation map in Russian, showing various star patterns and their names. The map is light blue and white, with stars represented by dots of varying sizes and lines connecting them to form constellations. Some constellations are labeled in Cyrillic, such as 'Возничий', 'Персей', 'Орион', and 'Зридан'.

# Contacts

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