Machine Learning-based Indoor Localization for Micro Aerial Vehicles

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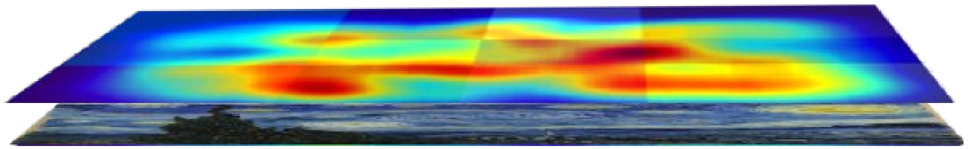

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Guido de Croon
Roland Meertens

OUTLINE

Motivation & Setting → Existing Methods → Method → Experiments & Results → Discussion & Conclusion

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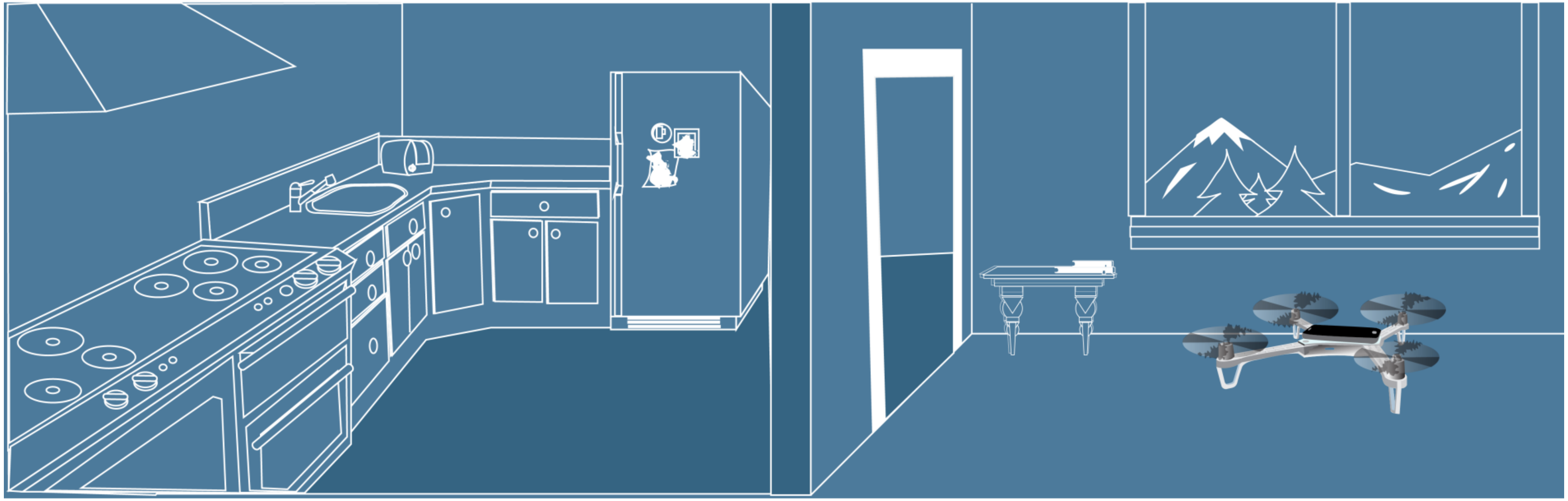
Motivation & Setting | Existing Methods | Method | Experiments & Results | Discussion & Conclusion

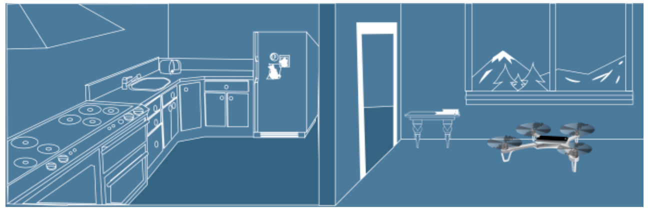
MOTIVATION



MOTIVATION

Tools

Environment

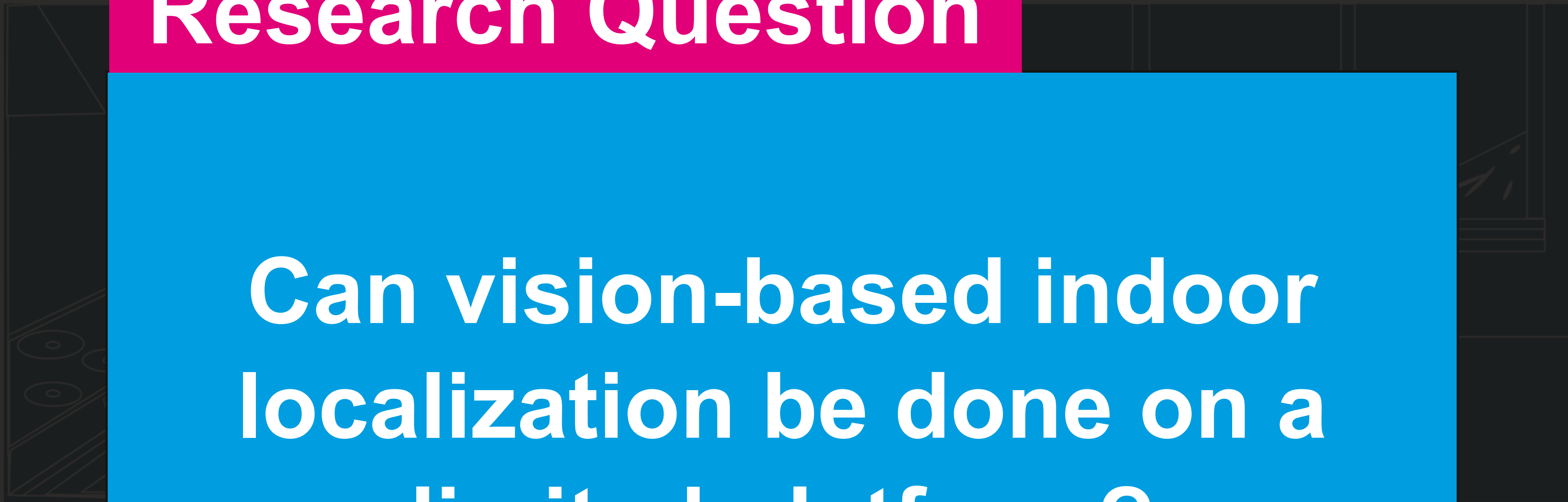


modifiable known fixed planar

x,y-coordinates

accurate on-board real-time

MOTIVATION



Research Question

Can vision-based indoor localization be done on a limited platform?

accurate

on-board

real-time

RESEARCH QUESTIONS

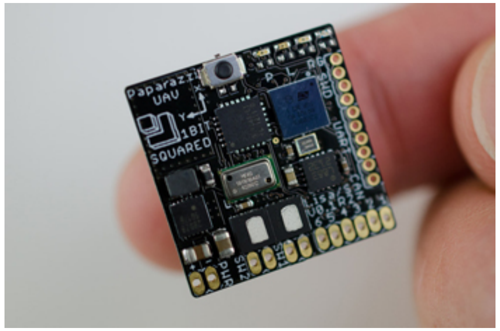
Research Question 1

Can vision-based indoor localization be done on a limited platform?

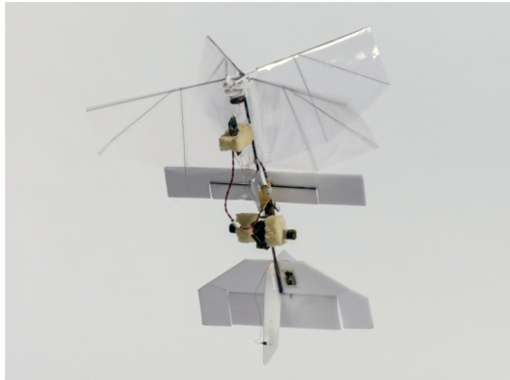
Research Question 2

Can we predict the suitability of an environment for the proposed localization algorithm?

Micro Air Vehicle Lab



Miniaturization



OUTLINE

Motivation & Setting

Existing Methods

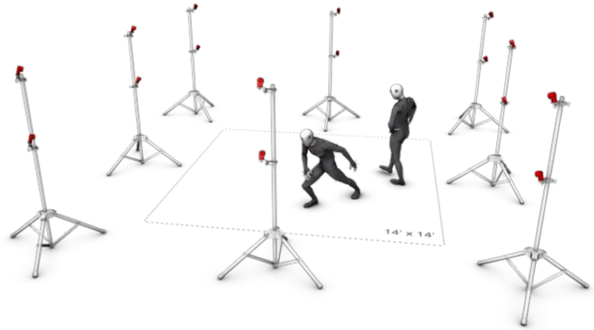
Method

Experiments & Results

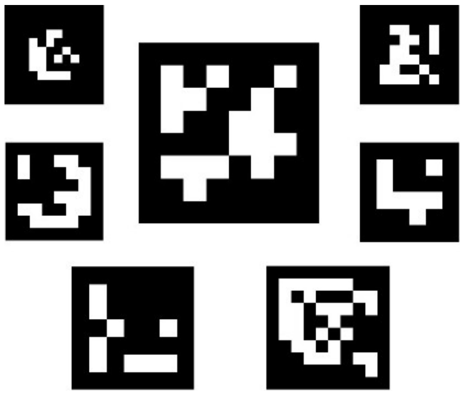
Discussion & Conclusion

METHODS FOR INDOOR LOCALIZATION

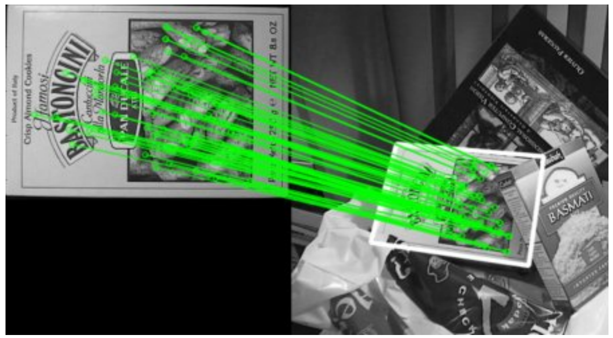
Laser range finder



Motion tracking system



Markers



SIFT + homography finding

DUMMY: INSERT SIFT VIDEO

APPROACH

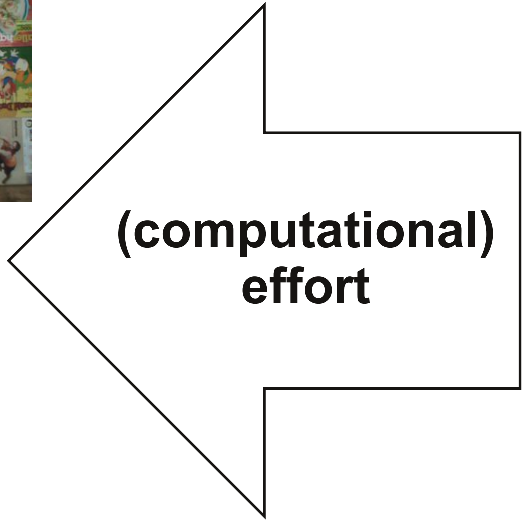
Flight phase

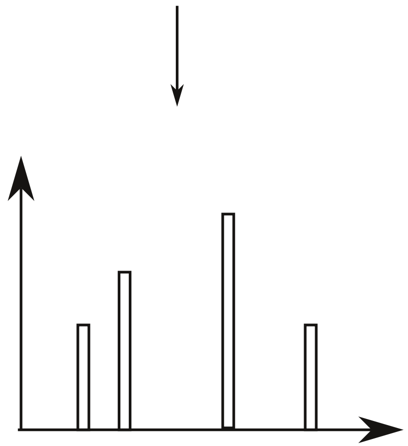
1 Image / sec

IDEA

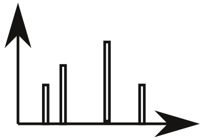
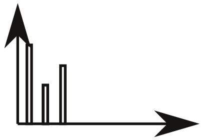
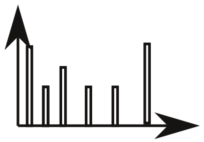
Preflight phase

Flight phase



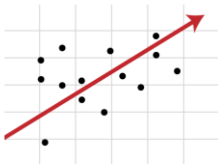


Training Data

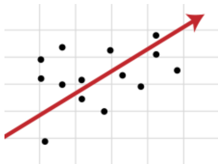
frequencies	x	y
	200	300
	700	210
⋮	⋮	⋮
	111	210

CHALLENGES / CONTRIBUTIONS

2-dimensional regression



x



y

Ground truth estimation

x?
y?

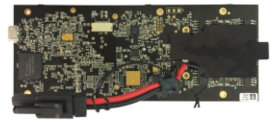
Which map is good?

CHALLENGES / CONTRIBUTIONS

Low-performance platform

Low-level embedded programming (C)



Real-world

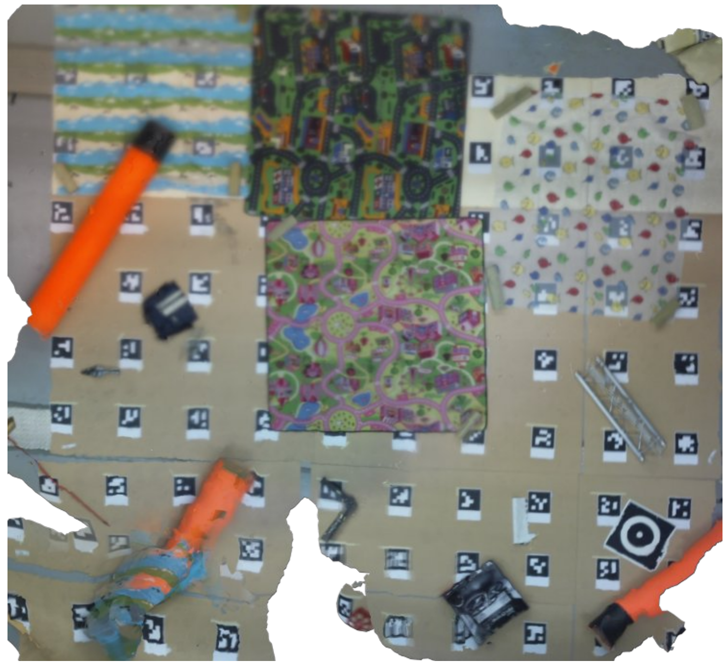
OUTLINE

Motivation & Setting | Existing Methods | **Methods** | Experiments & Results | Discussion & Conclusion

- Ground truth estimation
- Texton-based approach
- Particle Filter
- Map Evaluation

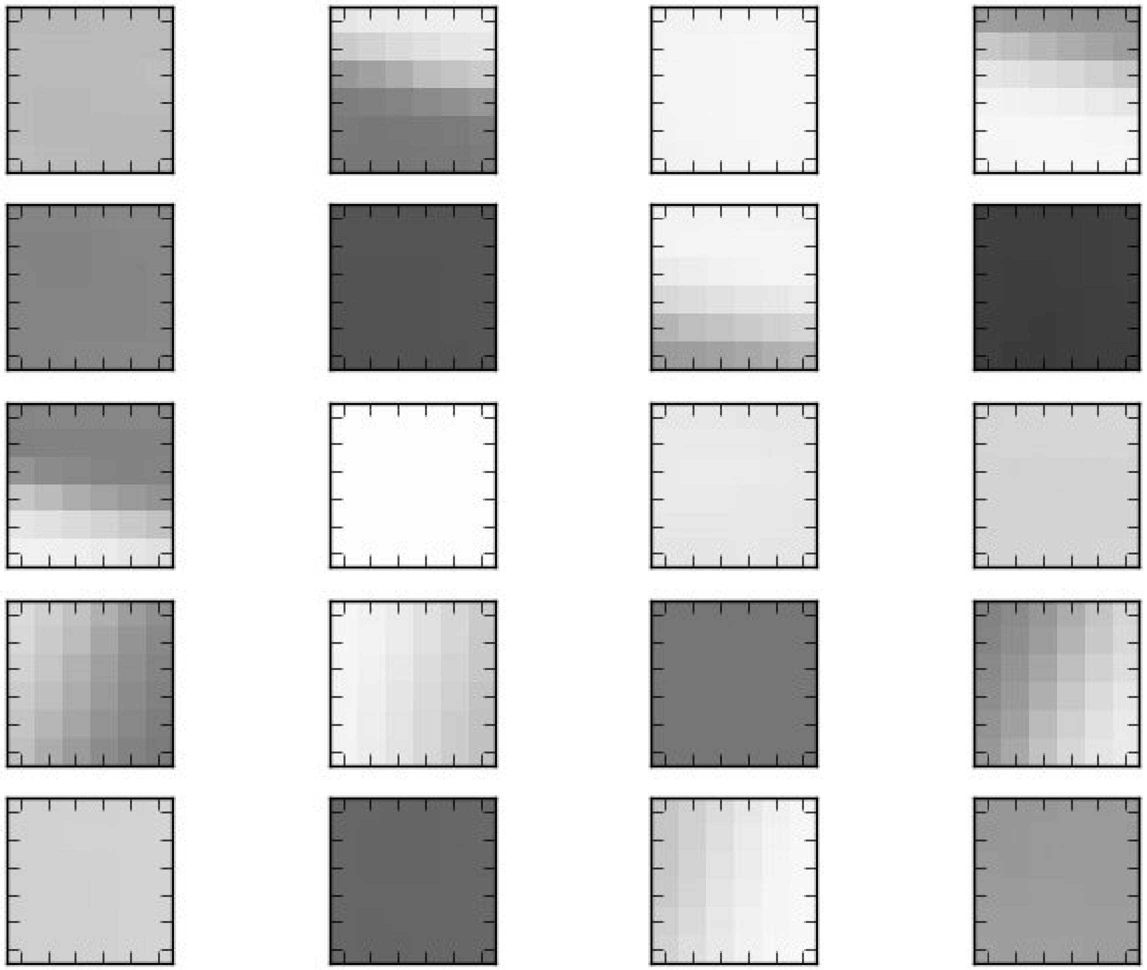
GROUND TRUTH ESTIMATION

GROUND TRUTH ESTIMATION

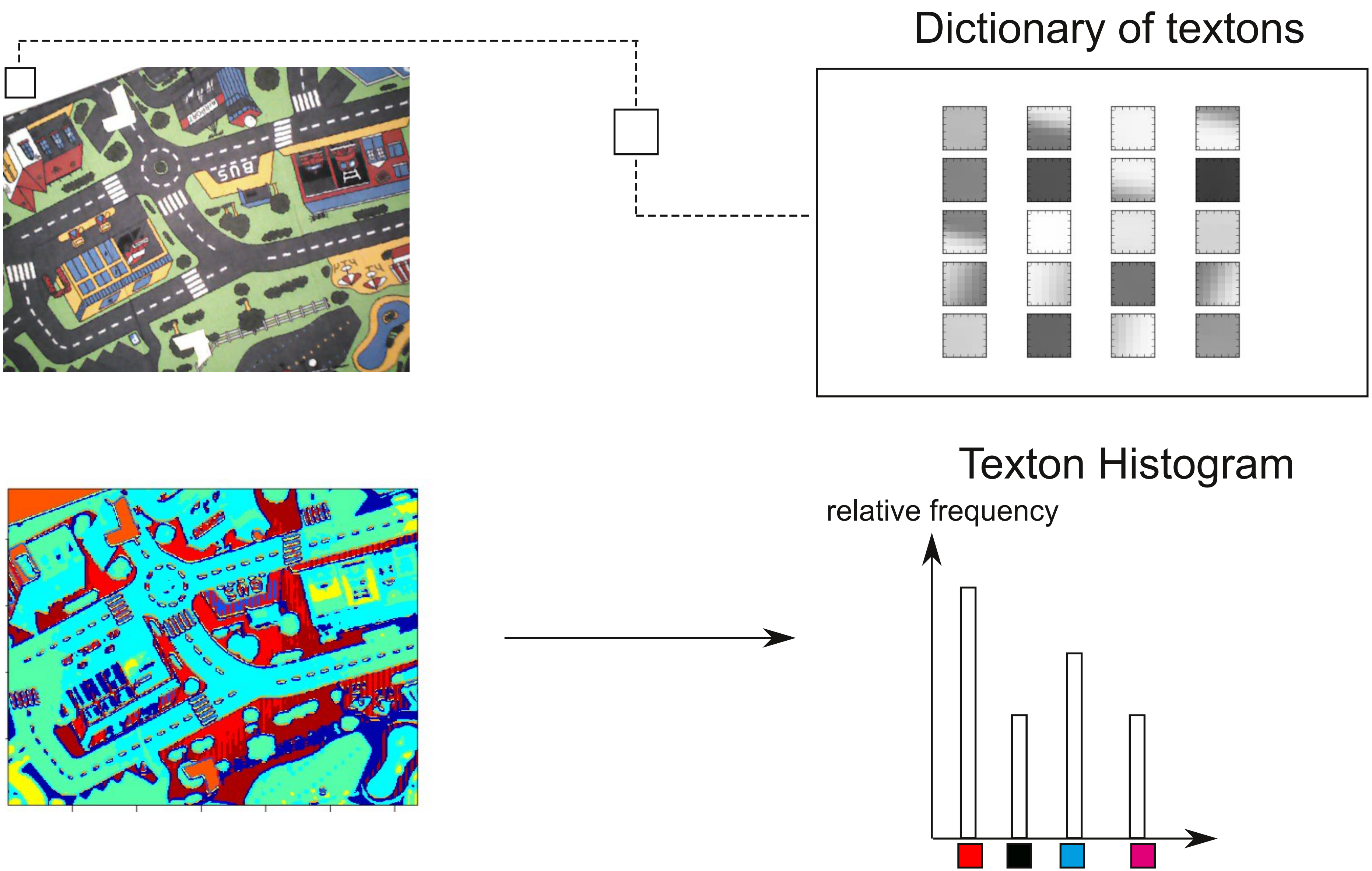


Orthomap

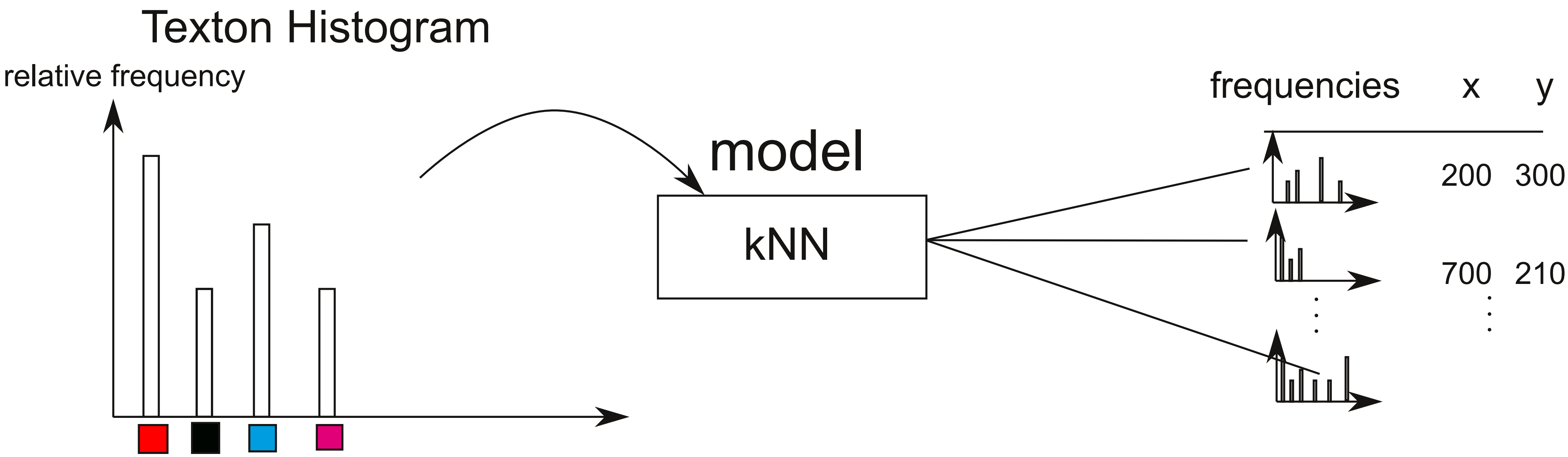
TEXTONS



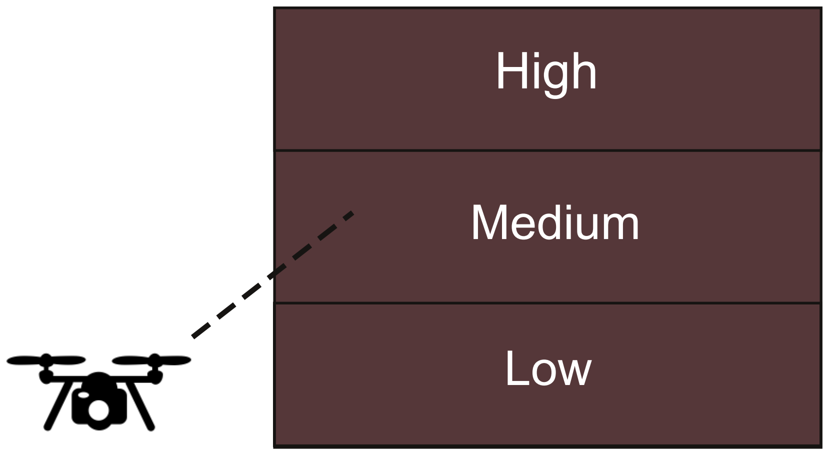
MACHINE-LEARNING APPROACH



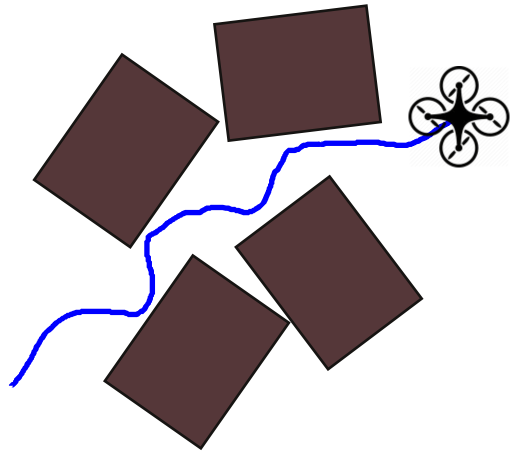
MACHINE-LEARNING APPROACH



FOUNDATION

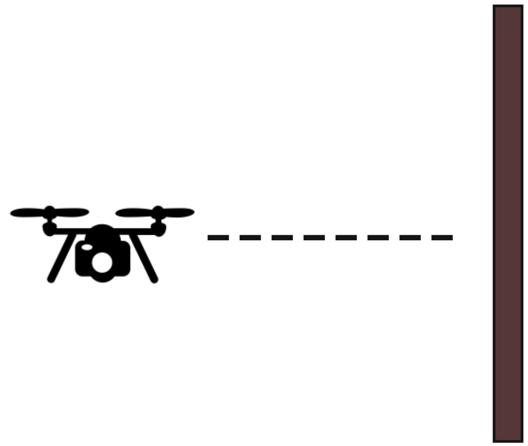


Height control



Obstacle Avoidance

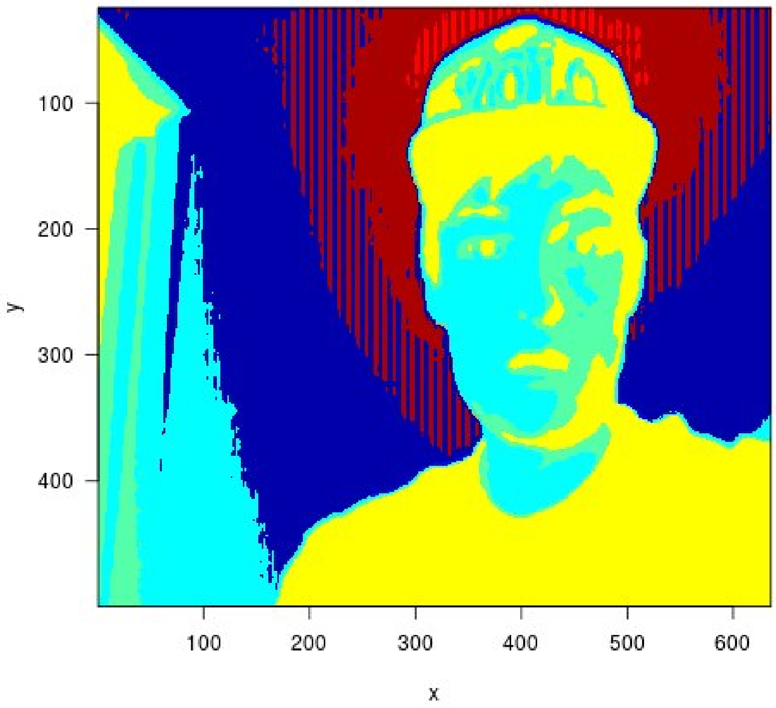
Safe Landing Spot Detection

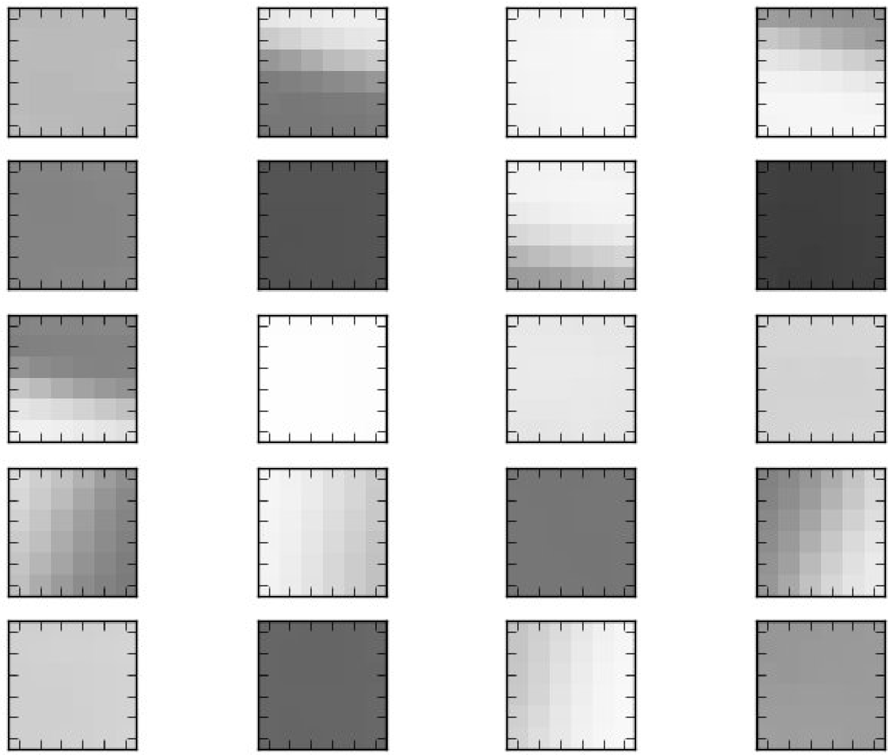


Distance Measurement

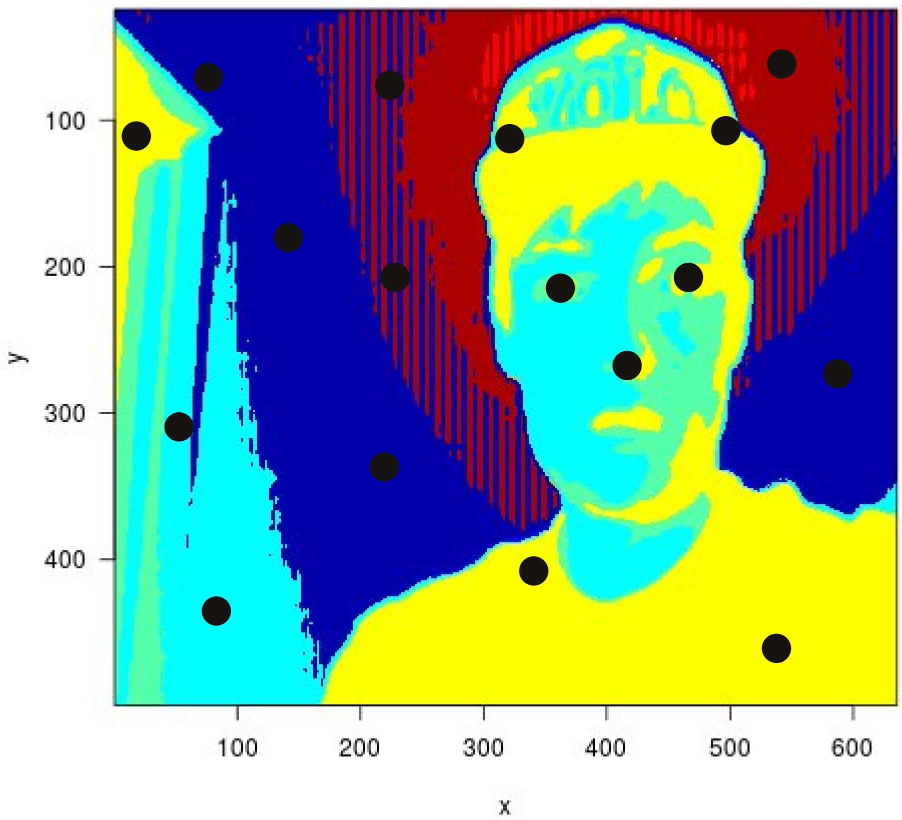
DUMMY: INSERT CYBERZOO_FLIGHT

MACHINE-LEARNING APPROACH



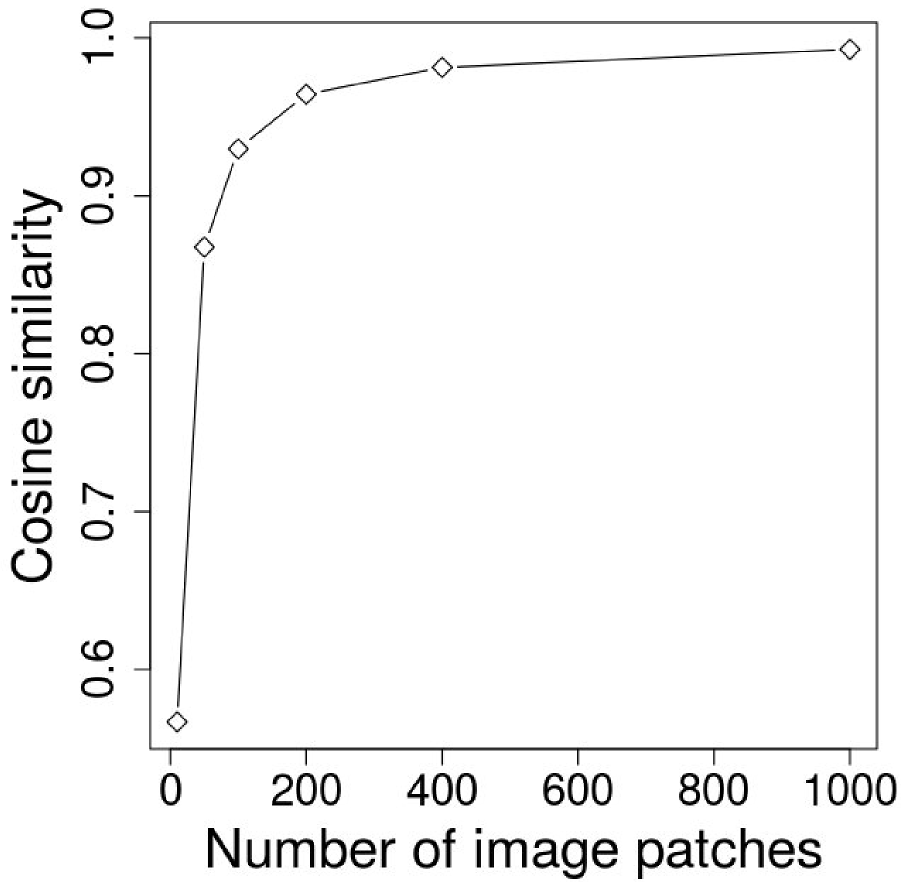


MACHINE-LEARNING APPROACH



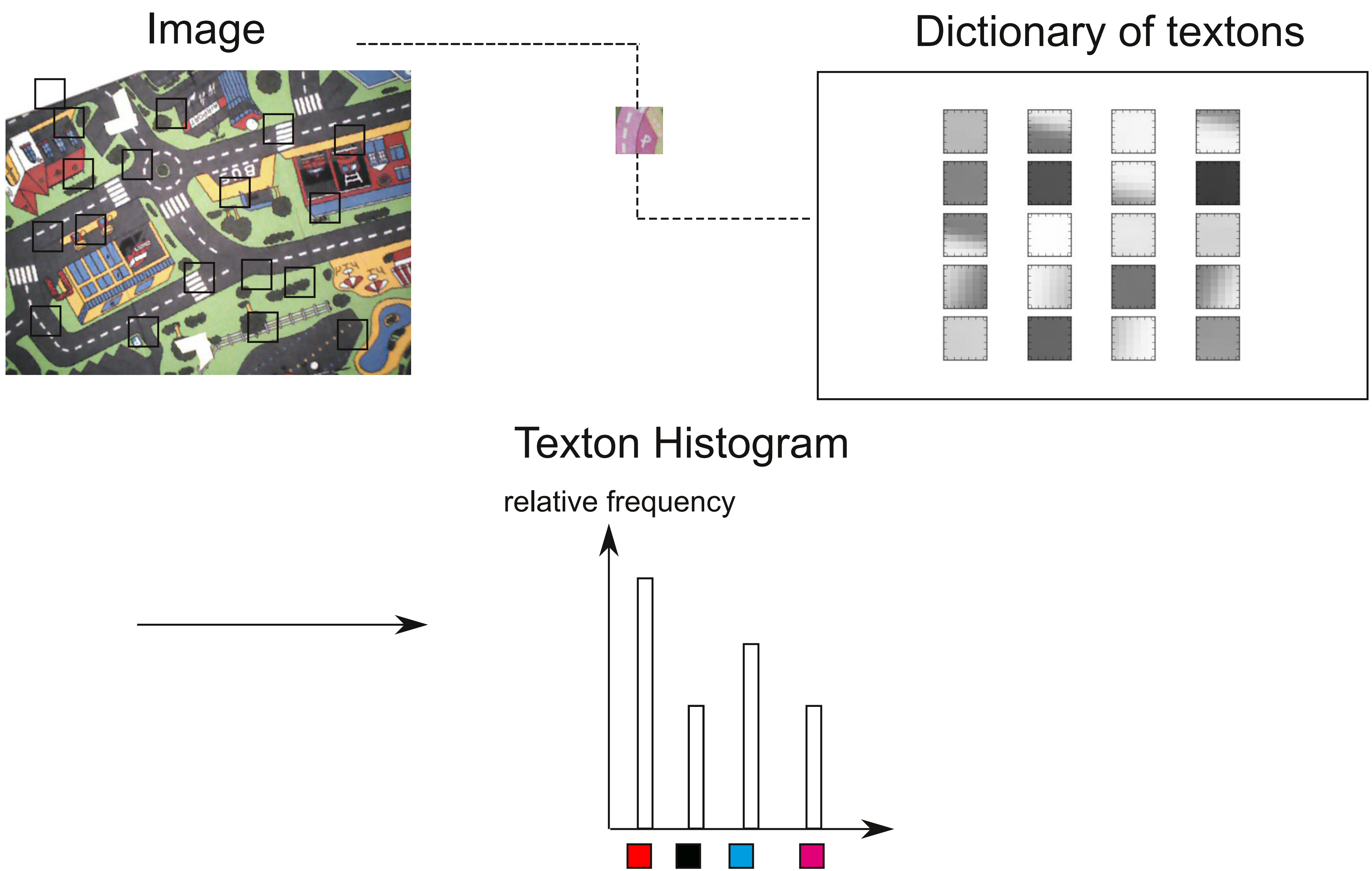
MACHINE-LEARNING APPROACH

307200!

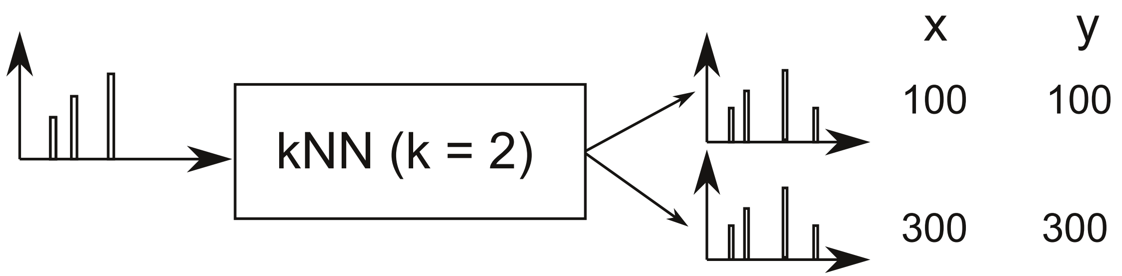


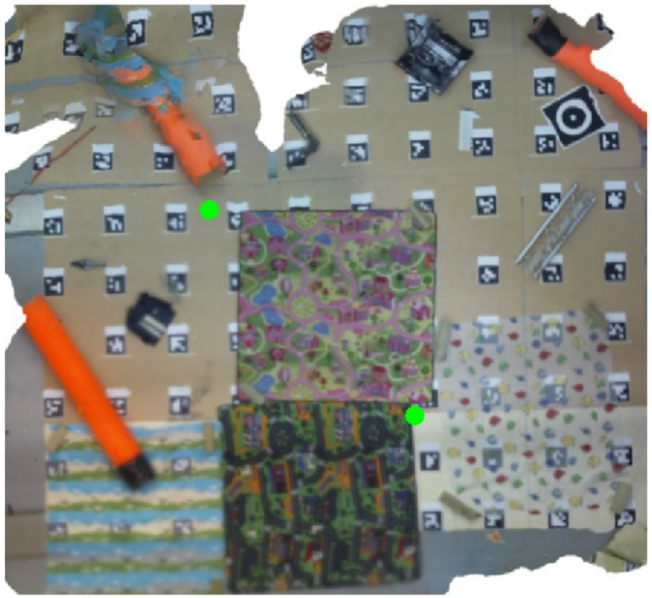
TODO: Standard deviations

MACHINE-LEARNING APPROACH



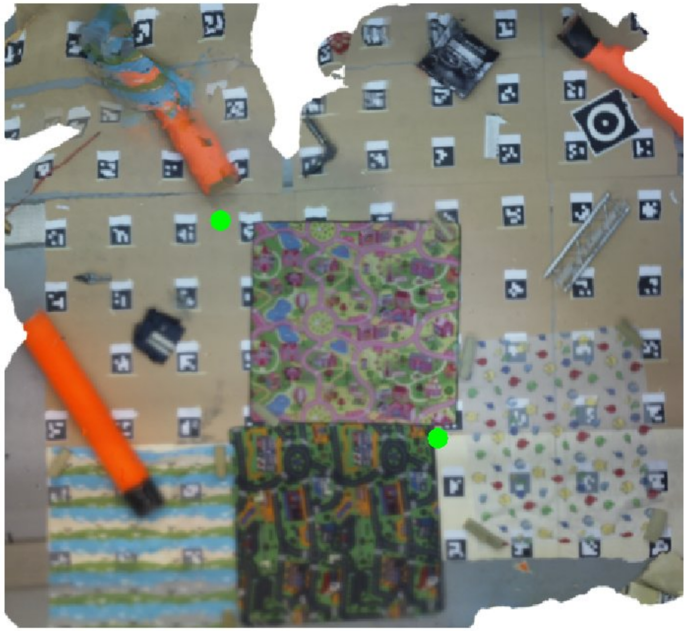
FILTERING





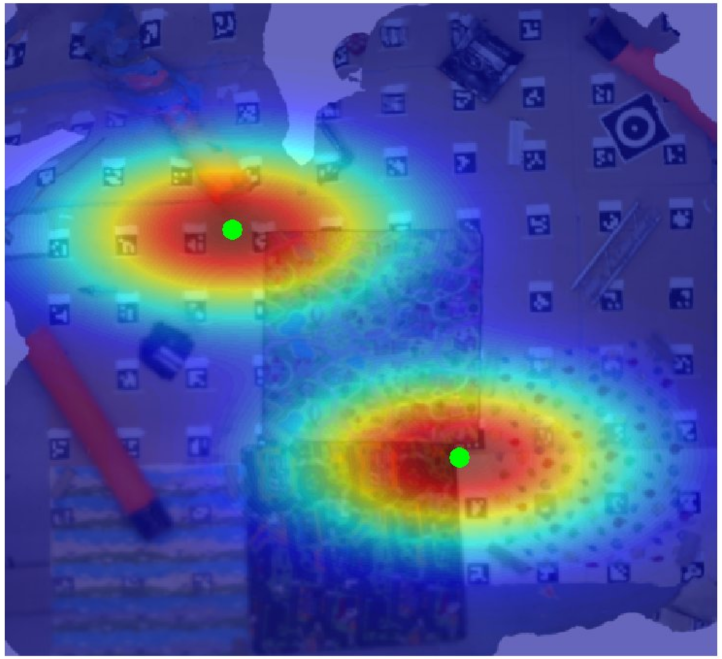
FILTERING

Sensor model



FILTERING

Sensor model

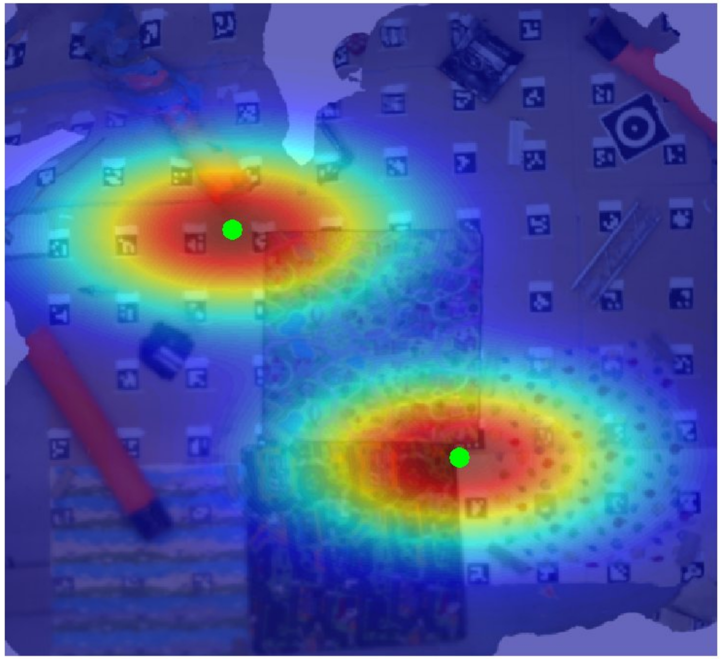


2-D Gaussian mixture model

FILTERING

Sensor model

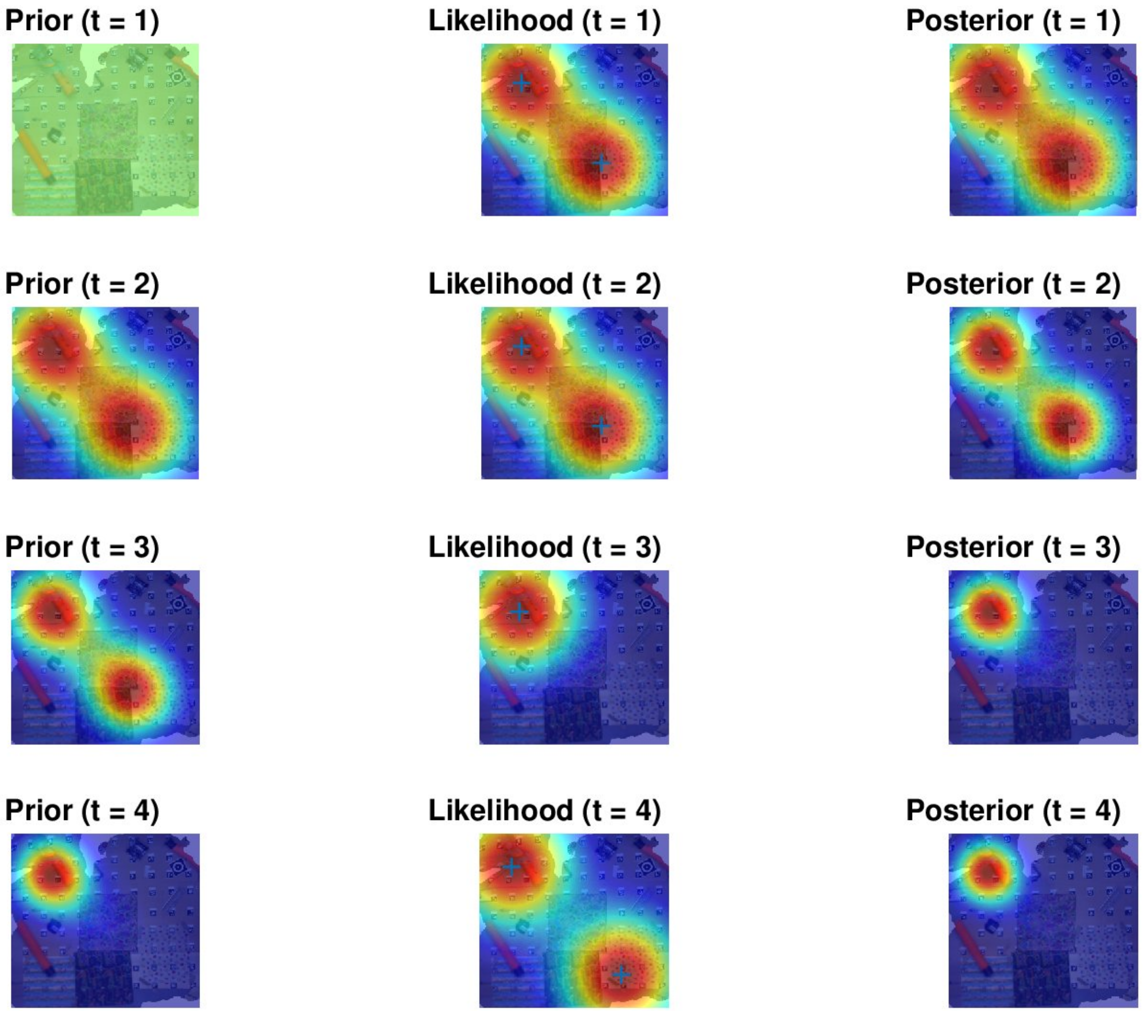
Motion model



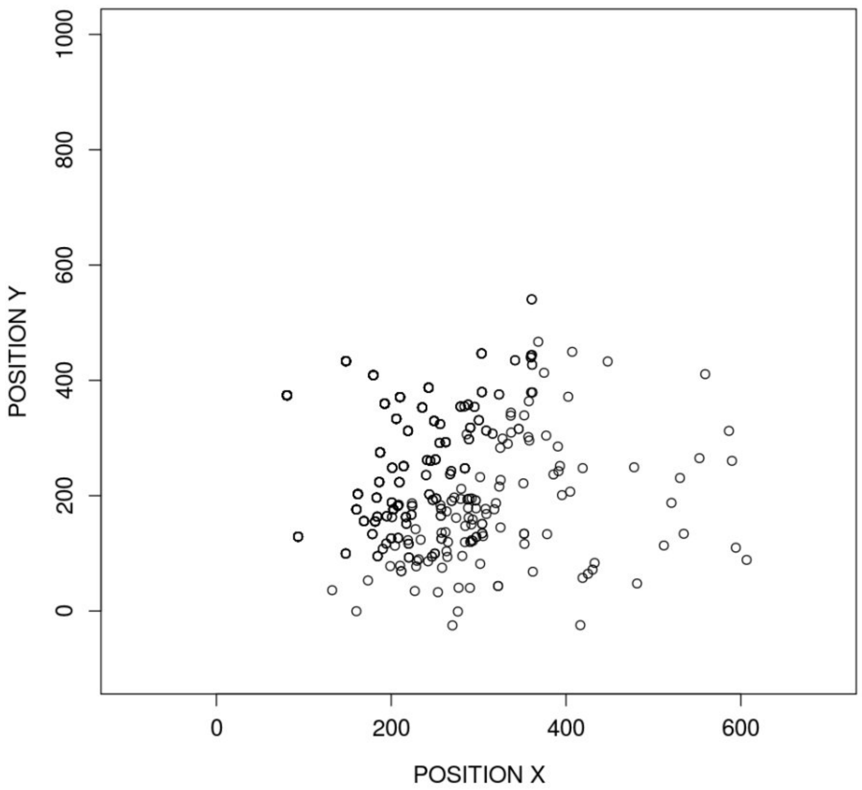
Gaussian noise

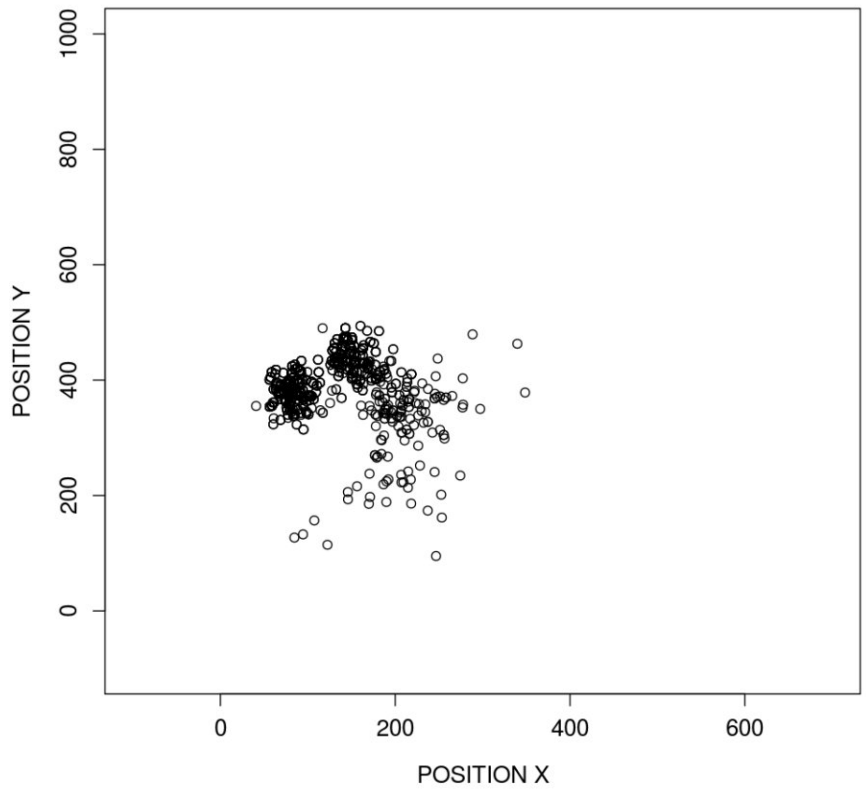
2-D Gaussian mixture model

FILTERING


Prior (t = 1)
Likelihood (t = 1)
Posterior (t = 1)
Prior (t = 2)
Likelihood (t = 2)
Posterior (t = 2)
Prior (t = 3)
Likelihood (t = 3)
Posterior (t = 3)
Prior (t = 4)
Likelihood (t = 4)
Posterior (t = 4)

PARTICLE FILTER

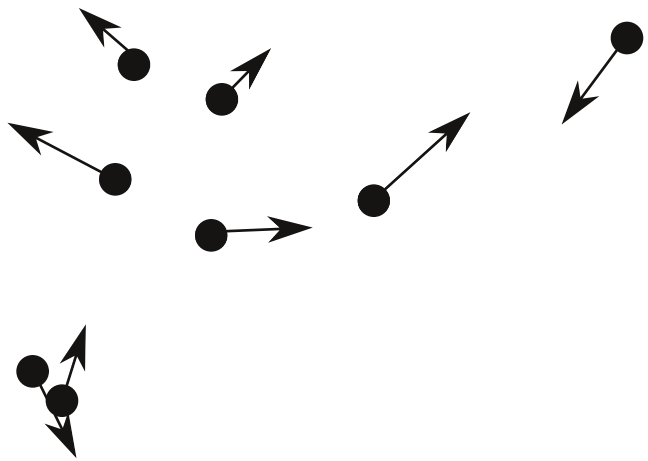




PARTICLE FILTER

Motion model

2D-Gaussian noise



TODO: Improve explanation of particle filter

DUMMY: VIDEO FAST FLIGHT

DUMMY: PARTICLE FILTER

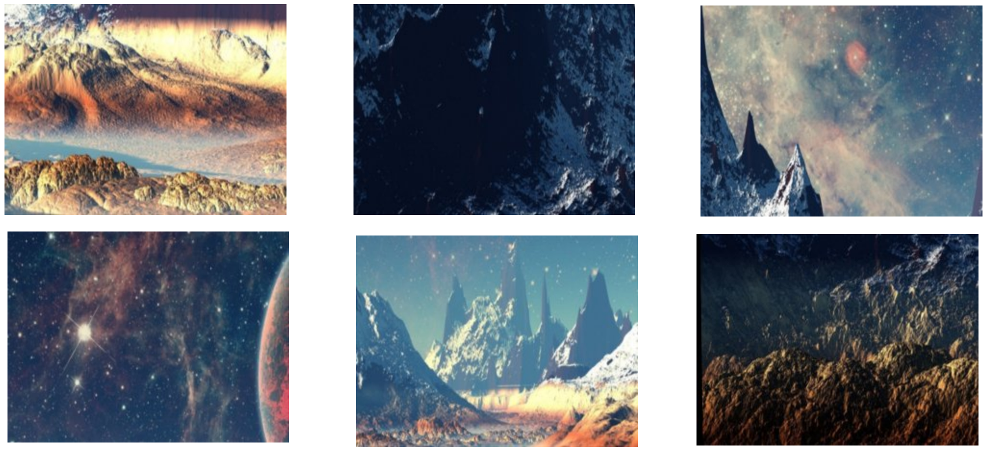
MAP EVALUATION

MAP EVALUATION

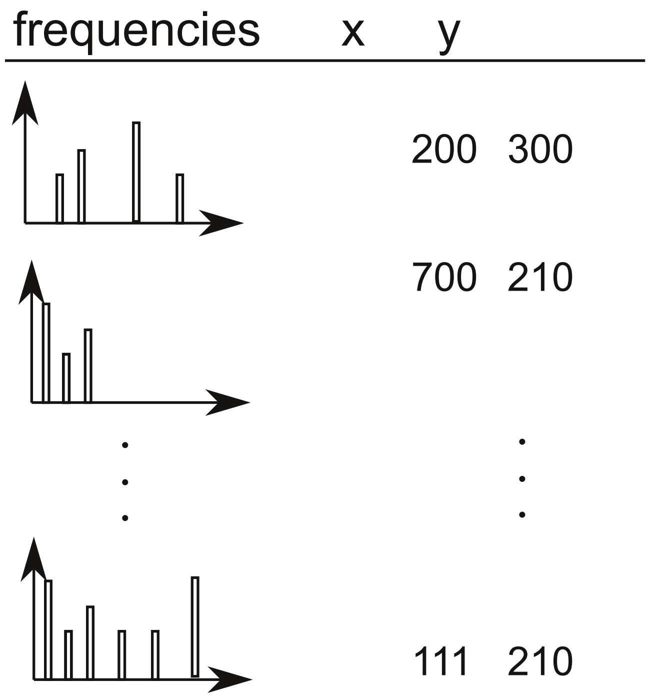
IDEAL SIMILARITY OF HISTOGRAMS FOR FIXED POSITION

MAP EVALUATION - SYNTHETIC FLIGHT

draug



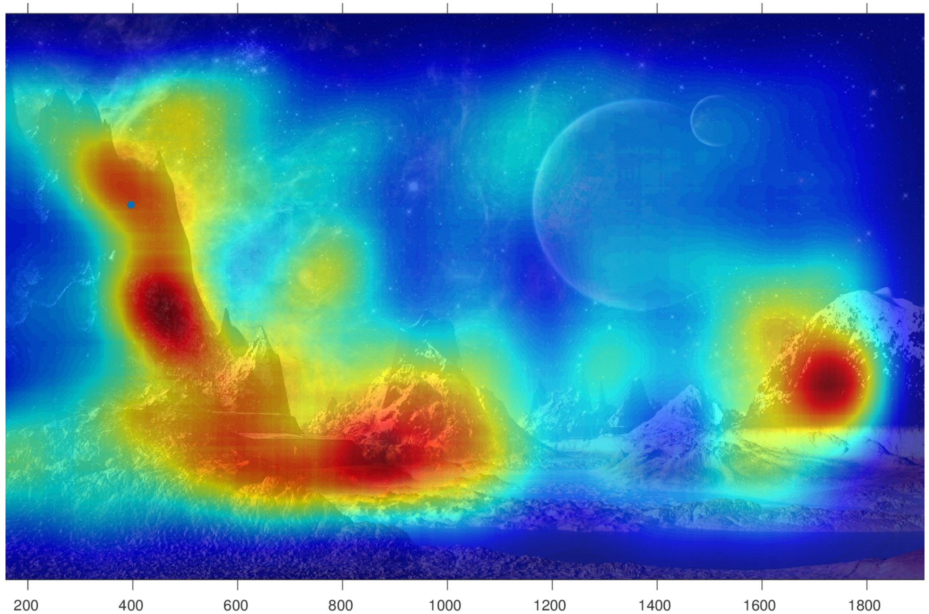
1000 patches



Training Data

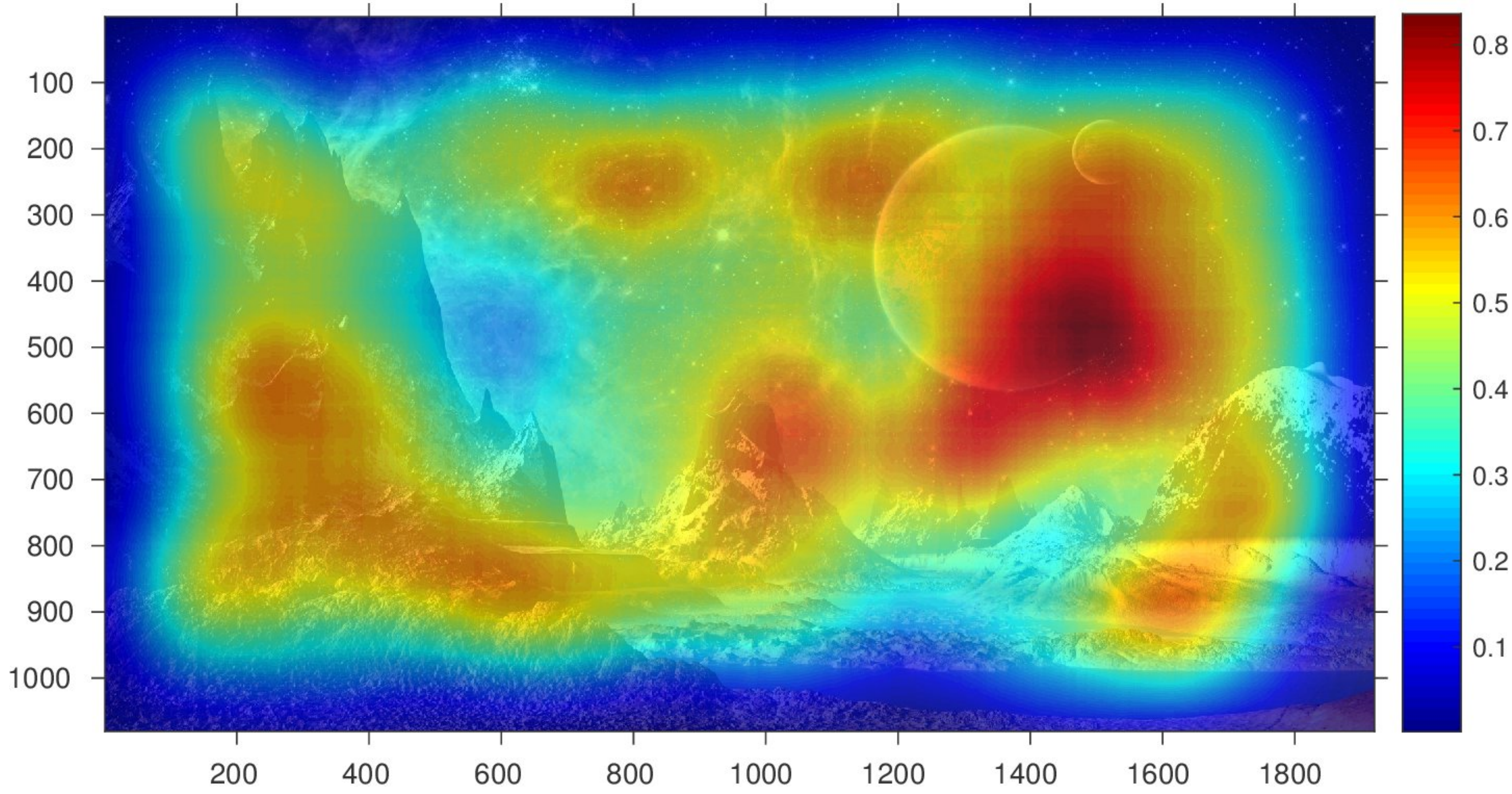
MAP EVALUATION

IDEAL SIMILARITY OF HISTOGRAMS FOR FIXED POSITION



ACTUAL SIMILARITY
(Gaussian smoothing)

MAP EVALUATION



GLOBAL LOSS (1000 patches)

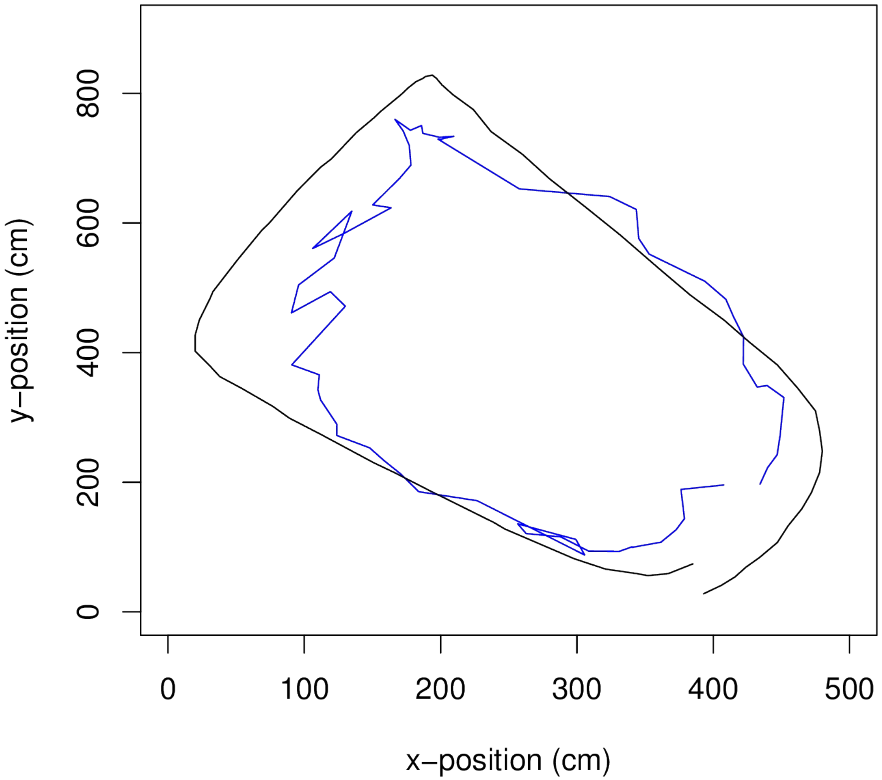
0 < global loss < 1

OUTLINE

Motivation & Setting → Existing Methods → Methods → **Experiments & Results** → Discussion & Conclusion

- OptiTrack vs. Textons
- Triggered Landing
- Map evaluation

FLIGHT ACCURACY



OptiTrack vs. treXton

4 Flights (400 images each)

Mean distance x: 46 cm

Mean distance y: 54 cm

SD distance x: 56 cm

SD distance y: 71 cm

Frequency: 10 Hz

TODO: split up into filter, texton, etc.

TRIGGERED LANDING

MAYBE:

PLOT DELTA X Y OF

SINGLE RUNS

OR USE TABLE

6 Landings

criterion:
distance < 60 cm

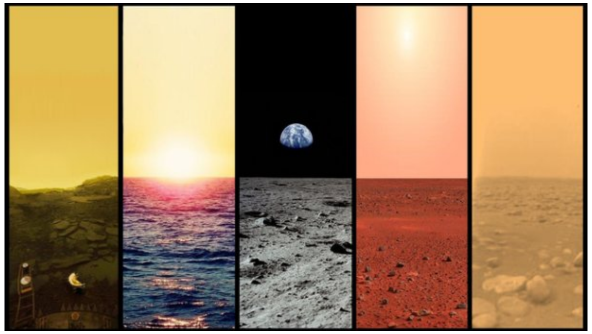
safety criterion:
low variance of particles

Mean distance: **51 cm**

SD distance: **17 cm**

DUMMY: VIDEO TRIGGERED LANDING

MAP EVALUATION

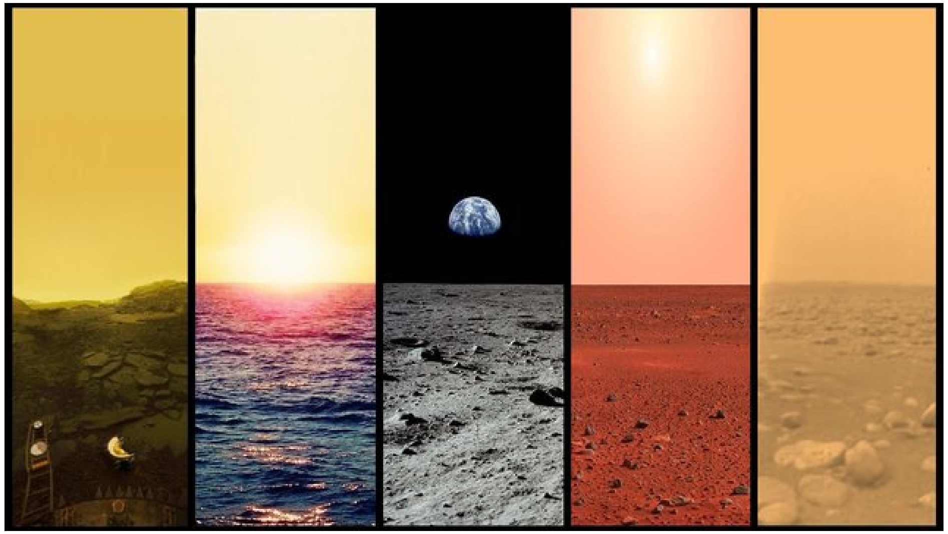


47 images

MAP EVALUATION - LOSSES

MAP EVALUATION

GOOD



0.57

BAD

0.98

OUTLINE

Motivation & Setting | Existing Methods | Methods | Experiments & Results | Discussion & Conclusion

RESEARCH QUESTIONS

Research Question 1

Can vision-based indoor localization be done on a limited platform?

Research Question 2

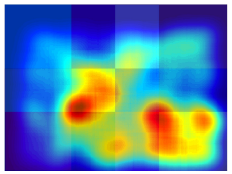
Can we predict the suitability of an environment for the proposed localization algorithm?

DISCUSSION

Implications:

- paves the way to indoor flight
- adaptable to different platforms

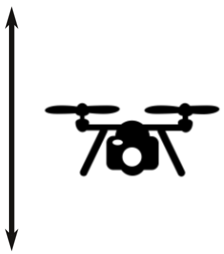
- detect safe landing spots

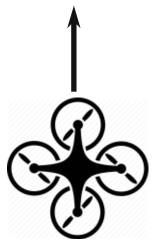


DISCUSSION

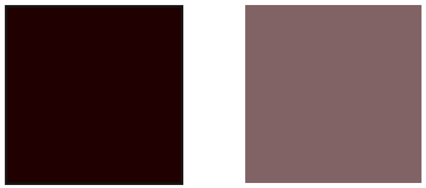
Limitations:

- assumes constant height and no rotations





- robustness to differerent lighting conditions

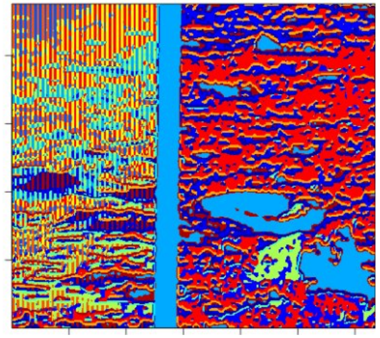


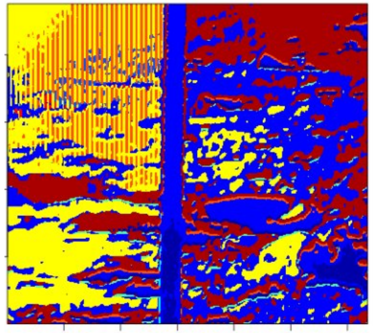
- Particle filter does not include velocity or heading

DISCUSSION

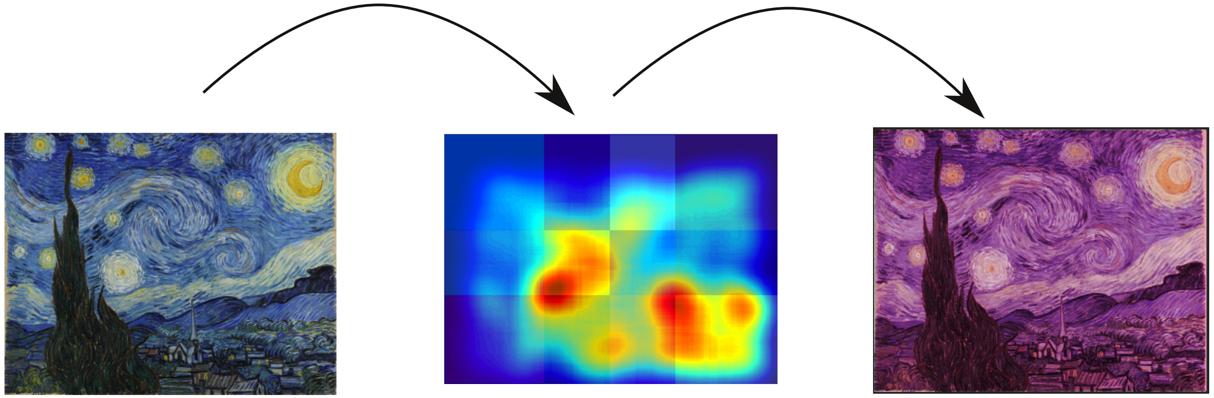
Future research:

- bridge reality gap





- automatic map generation (evolutionary algorithm)



CODE CONTRIBUTIONS

- draug: Image augmentation with synthetic views (C++)

  https://github.com/Pold87/draug

- Map evaluation (MATLAB)

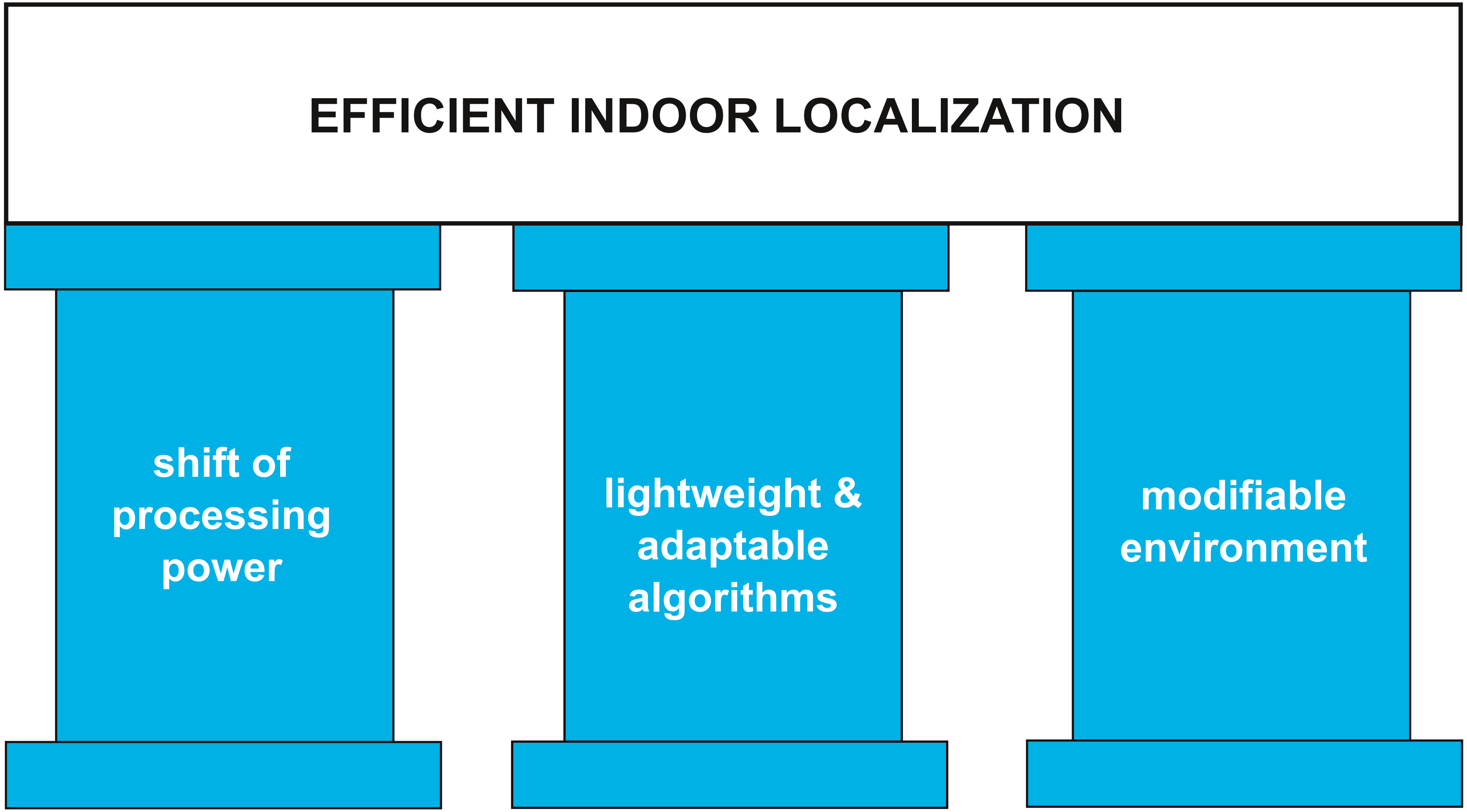
  https://github.com/Pold87/evaluation-thesis

- Localization: SIFT matching (C++), particle filter (C), texton-based approach (C)

  TODO: PULL REQUEST C: https://github.com/Pold87/paparazzi   Python: https://github.com/Pold87/treXton

PAPARAZZI
The Free Autopilot

CONCLUSION


EFFICIENT INDOOR LOCALIZATION
shift of processing power
lightweight & adaptable algorithms
modifiable environment