Detection of refugee boats on the Mediterranean with a drone by using FOSS

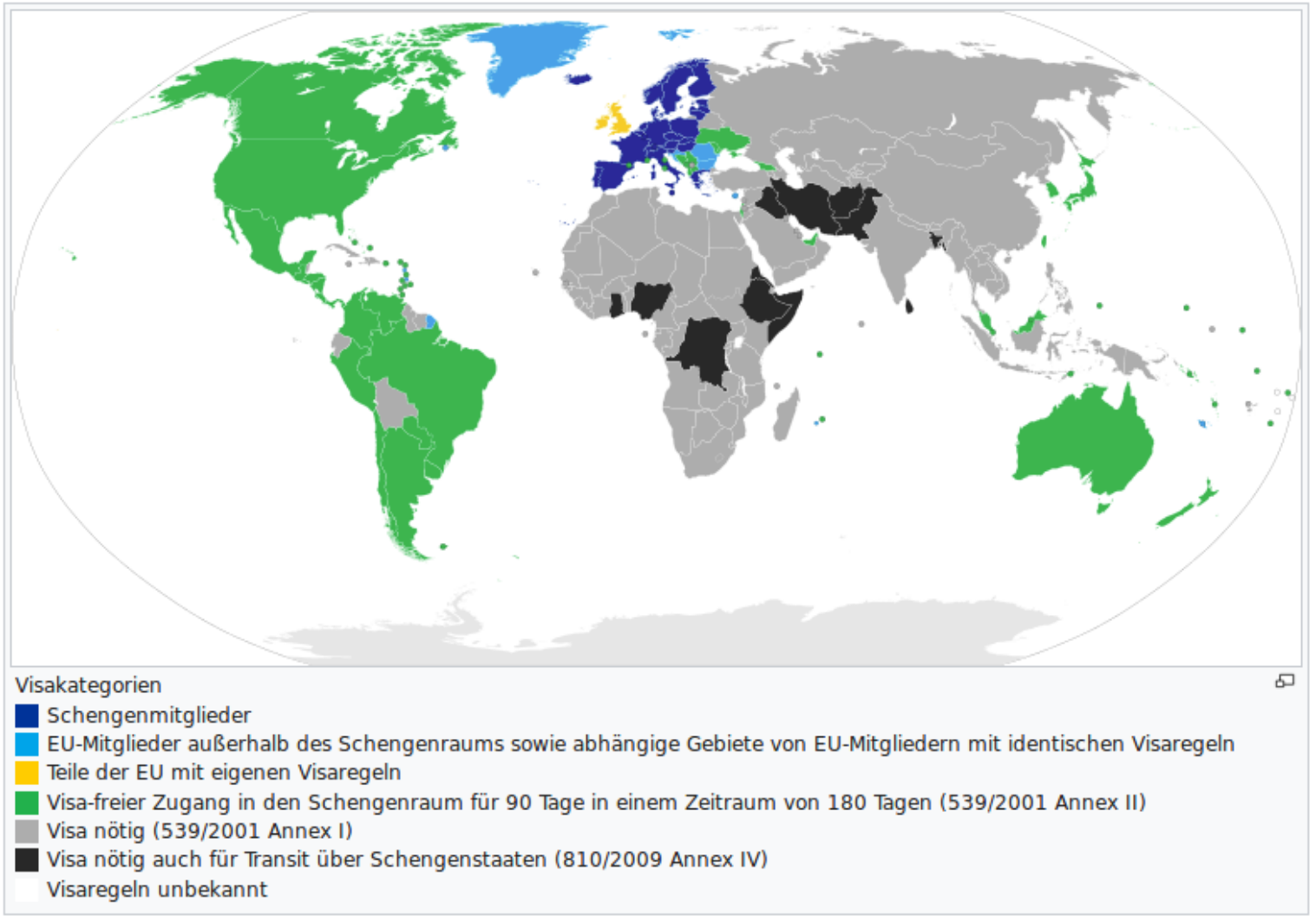
- Introduction
  - Refugee routes on the Mediterranean
  - Search & Rescue (SAR)
- SearchWing: SAR Drone
  - Requirements
  - Plane Hardware / Software
  - Computer vision
  - Current progress
  - Current work packages
- Free open source frameworks

Introduction
Refugee routes on the mediterranean

- Impossible routes
  - By ferry
  - By plane
- Possible live risking and inhumane routes
  - By rubber boat

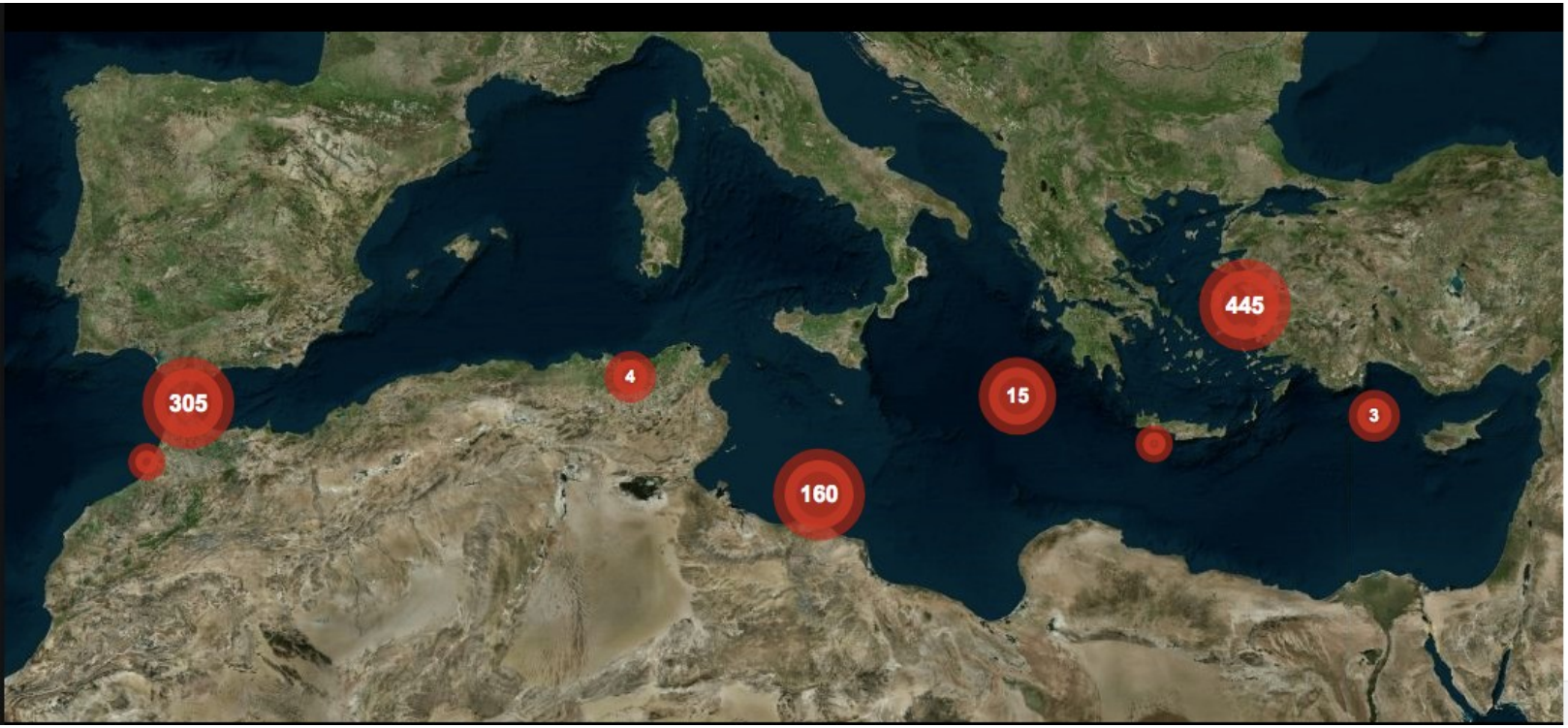
Introduction
Refugee routes on the mediterranean

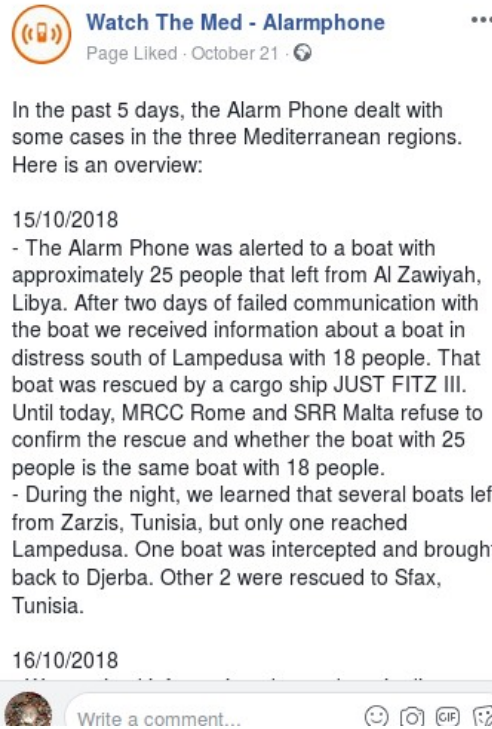
- VISA laws origin
  - EU Council Regulation 539/2001 Annex I (15.3.2001)



Introduction
Refugee routes on the mediterranean

- Overview on emergencys at the sea




Watch The Med - Alarmphone
Page Liked · October 21 ·

In the past 5 days, the Alarm Phone dealt with some cases in the three Mediterranean regions. Here is an overview:

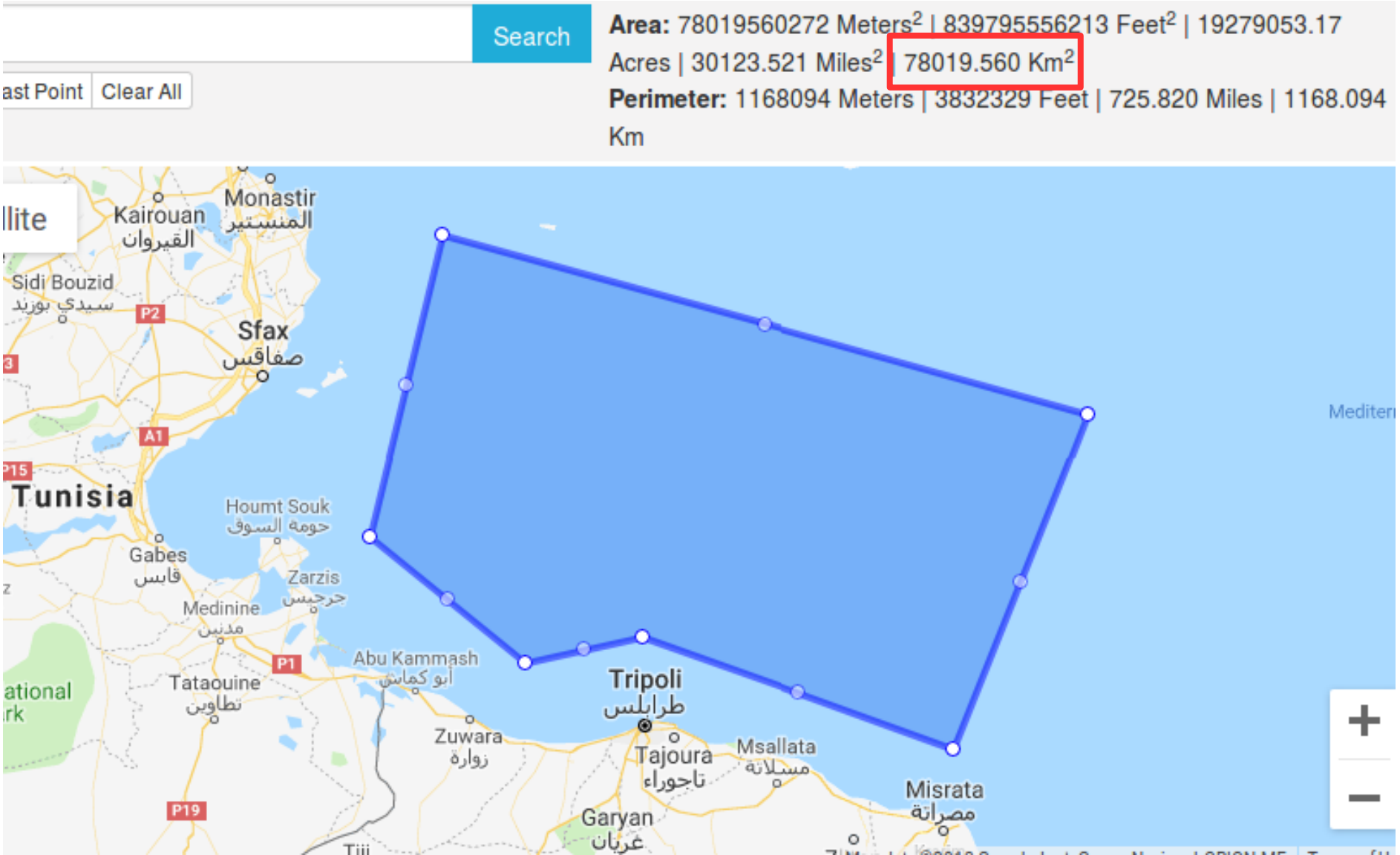
15/10/2018
- The Alarm Phone was alerted to a boat with approximately 25 people that left from Al Zawiyah, Libya. After two days of failed communication with the boat we received information about a boat in distress south of Lampedusa with 18 people. That boat was rescued by a cargo ship JUST FITZ III. Until today, MRCC Rome and SRR Malta refuse to confirm the rescue and whether the boat with 25 people is the same boat with 18 people.
- During the night, we learned that several boats lef from Zarzis, Tunisia, but only one reached Lampedusa. One boat was intercepted and brough back to Djerba. Other 2 were rescued to Sfax, Tunisia.

16/10/2018

Write a comment...

Introduction
Search & Rescue (SAR)

- Size of the area: ~80.000km²



Introduction
Search & Rescue (SAR)

- Governmental: Frontex / EUROSUR
  - The European Border Surveillance system (EUROSUR)
  - Search ~~& Rescue~~
  - Hightech surveillance system
    - Satellites: RADAR / Optical
    - Drones
    - Planes
    - Ballons
    - Live-Streams
  - „Seeaußengrenzenverordnung“
    - Alert MRCC in case of emergency

FRONTEX EUROSUR SERVICES HELP RESCUE 370 PEOPLE OFF LIBYAN COAST

2015-10-09

More than 370 people were rescued off the Libyan coast this week after their vessels were detected on satellite images taken as part of Frontex's Eurosur Fusion Services. The operation was made possible by the cooperation between experts at Frontex and the European Maritime Safety Agency (EMSA), Italian authorities and EUNAVFORMED.

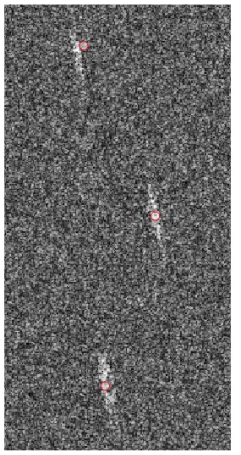
On Tuesday, 6 October, Frontex Situation Centre in cooperation with EMSA spotted several small boats on a satellite scan of an area close to the Libyan coast, where migrant boats in distress are often detected. The information was passed on to the Italian authorities, which informed the EUNAVFORMED flagship Cavour present in the area.

As a result, more than 370 migrants aboard three rubber boats were rescued and brought to the Italian shores. The people included nine children and four pregnant women.

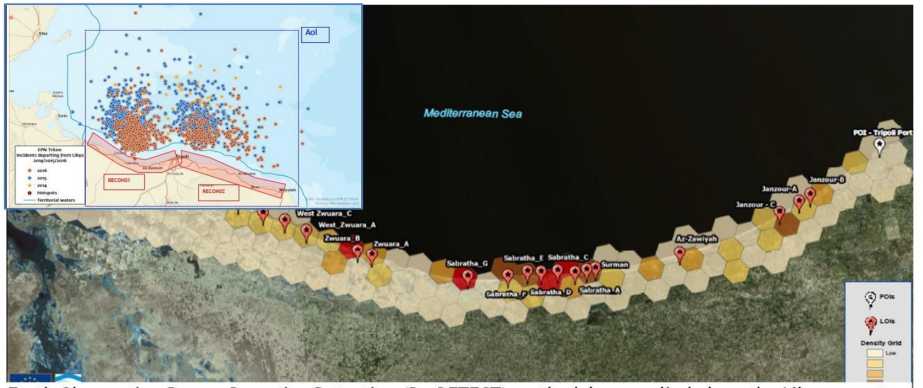
Eurosur is an information exchange framework designed to improve the management of Europe's external borders.

The Eurosur services already include automated large vessel tracking and detection capabilities, software functionalities allowing complex calculations for predicting positions and detecting suspicious activities of vessels, as well as precise weather and oceanographic forecasts. Fusion Services use optical and radar satellite technology to help locate vessels at sea. Recent upgrades of their technical capabilities make it possible to spot smaller vessels.

Last month, the Greek Coast Guard seized some 5 000 guns and boxes with ammunition aboard a Libya-bound cargo ship that had been monitored by Frontex as part of the Eurosur Fusion Services.



Satellite image with the rubber boats spotted near Libyan coast



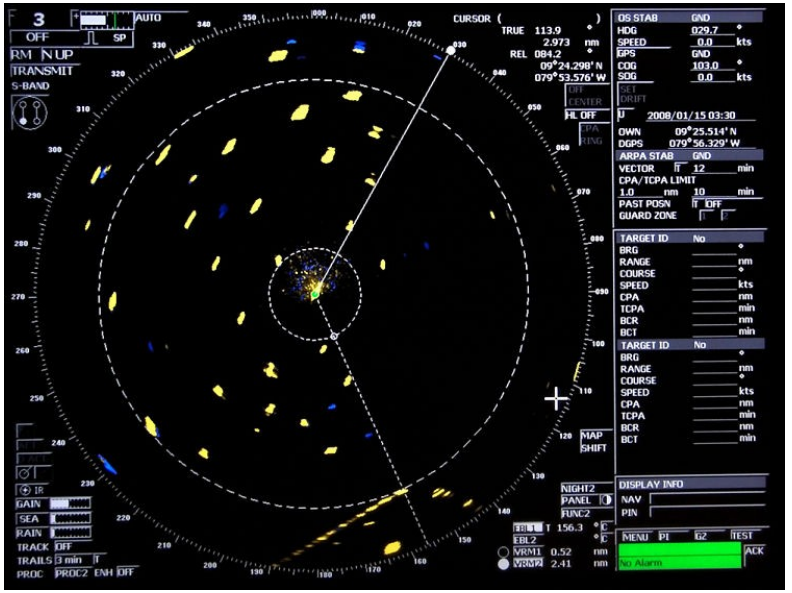
Earth Observation Recon. Proactive Detection (ProDETECT) methodology applied along the Libyan coasts

https://netzpolitik.org/2018/der-europaeische-grenzgeheimdienst/

https://web.archive.org/web/20170619170732/http://frontex.europa.eu/news/frontex-eurosur-services-help-rescue-370-people-off-libyan-coast-MxXy7S

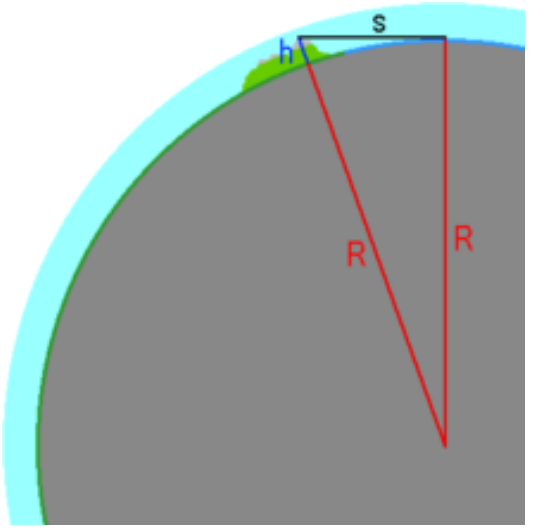
Introduction
Search & Rescue (SAR)

- NGOs: Ships
  - Search & Rescue
  - ~ 100km² / hour
  - RADAR
    - Low resolution
    - Lots of noise
    - ~10km
  - Binoculars
    - Limited distance
    - Exhausting
    - ~8km



Introduction
Search & Rescue (SAR)

- Limited sight distance due to round earth

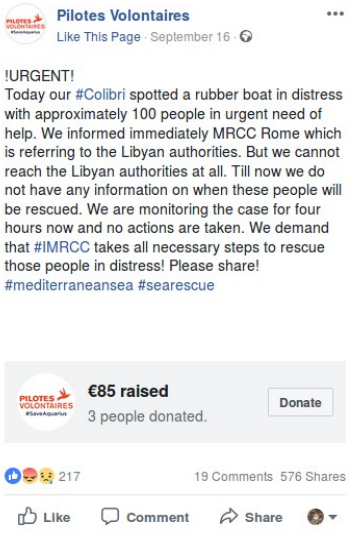


Augenhöhe	Sichtweite	Augenhöhe	Sichtweite	Augenhöhe	Sichtweite	Augenhöhe	Sichtweite
1 m	3,6 km	10 m	11 km	100 m	35 km	1000 m	112 km
2 m	5,0 km	20 m	16 km	200 m	50 km	2000 m	159 km
3 m	6,1 km	30 m	19 km	300 m	61 km	3000 m	195 km
4 m	7,1 km	40 m	22 km	400 m	71 km	4000 m	225 km
5 m	8,0 km	50 m	25 km	500 m	79 km	5000 m	252 km
6 m	8,7 km	60 m	27 km	600 m	87 km	6000 m	276 km
7 m	9,4 km	70 m	29 km	700 m	94 km	7000 m	298 km
8 m	10,0 km	80 m	31 km	800 m	100 km	8000 m	319 km
9 m	10,7 km	90 m	33 km	900 m	107 km	9000 m	338 km

https://de.wikipedia.org/wiki/Sichtweite

Introduction
Search & Rescue (SAR)

- NGOs: Planes
  - Currently two organisations: Moonbird, Pilotes Volontaires
  - Takes hours to arrive at SAR-zone
  - Cover ~3000km² of the SAR-zone / flight



Introduction
Search & Rescue (SAR)

- NGOs: Needs
  - Have a long distance eye in the sky on spot
  - Detect boats near the ship
- Two projects to solve the needs partially
  - Use a drone to start a flight directly from the ship
  - Use a boat mounted camera to scan the horizont

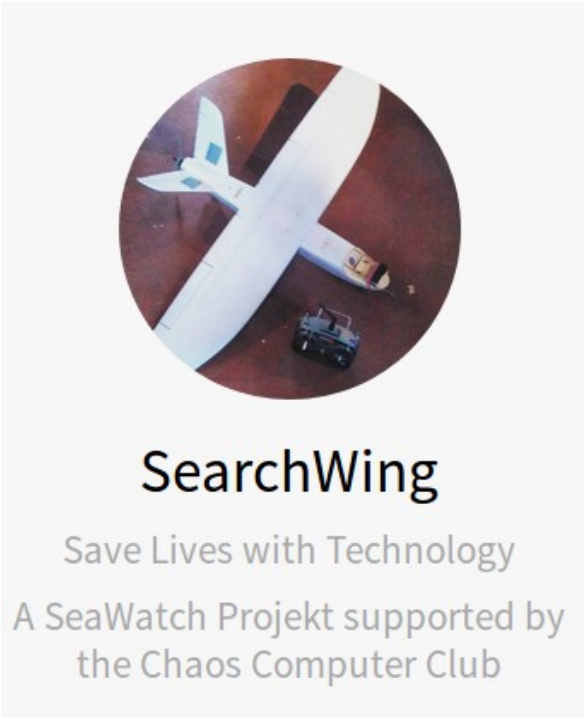
Searchwing
SAR Drone

- Loose group of people
  - Berlin:

    https://www.searchwing.org/
  - Augsburg:

    https://www.hs-augsburg.de/Elektrotechnik/SearchWing.html
- Work on software / hardware

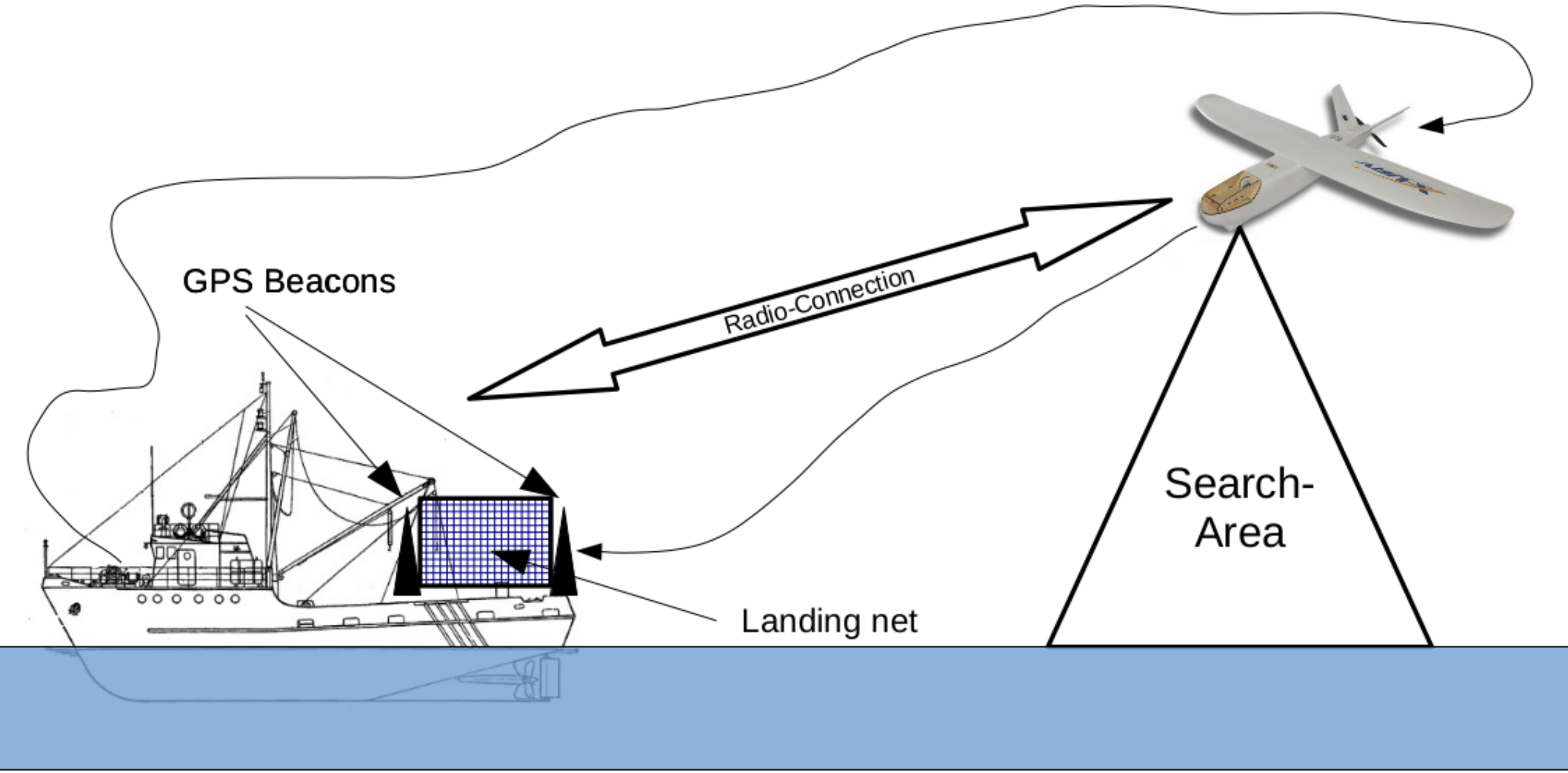
  for maritime SAR



Searchwing Requirements

- Search boats / document human rights violations
- Fully automated flight
  - Start from hand
  - Multiple waypoints
  - Land in net
- Range > 50km
- Automatically detect boats
  - Too low bandwidth (~100kbit/s) for live video due to high distance to ship
  - Send images of detected boats
  - Missing boats / false negatives are not allowed
- Cheap due to possible lost / leave back when ship needs to leave
- Easy usage (Ideally no special knowledge required)

Searchwing
Plane Hardware



Searchwing Plane Hardware

- Parts / prices

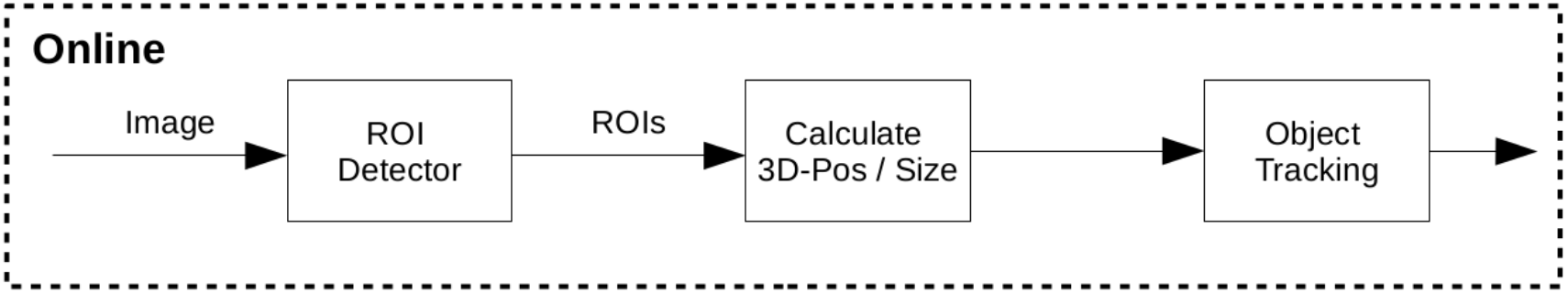
Type	Name	Price €
DIY Plane	Mini Talon UAV	70
Flight Controller	pixRacer	70
CPU	Raspberry PI3	40
Camera	PI Cam v2	20
Battery		70
Motors		40
Radio / Modem	RFD 900X(50km)	100
Servo		10
Propeller		10
Etc		20
		~450

Searchwing
Plane software

- Userinput: GPS Waypoints
- Automated start / flight
  - Using plane controller sensors
  - Using ardupilot / px4 framework
- Automated land
  - Calculate exact position of landing net by using differential gps
  - Correct landing trajectory to ship automatically by using guided mode
- Send detections from computer vision part to ship
  - Only cut out of the objectpicture needs to be transmitted
  - For example: 29x27pix, jpg, 5 kbyte => ~0,4 sec @ 100kBit/s
  - Human in the loop

Searchwing
Computer vision

- Boatdetection by tracking
  - Detect Regions of Interest (ROIs) in images and track them over time
  - Assumption: Boat ROIs stay nearly at same pos over time
  - Assumption: Nature ROIs (e.g. wave) do not stay over time
  - Pro: No classifier needed
  - Con: Good motion selfestimation & calibration needed

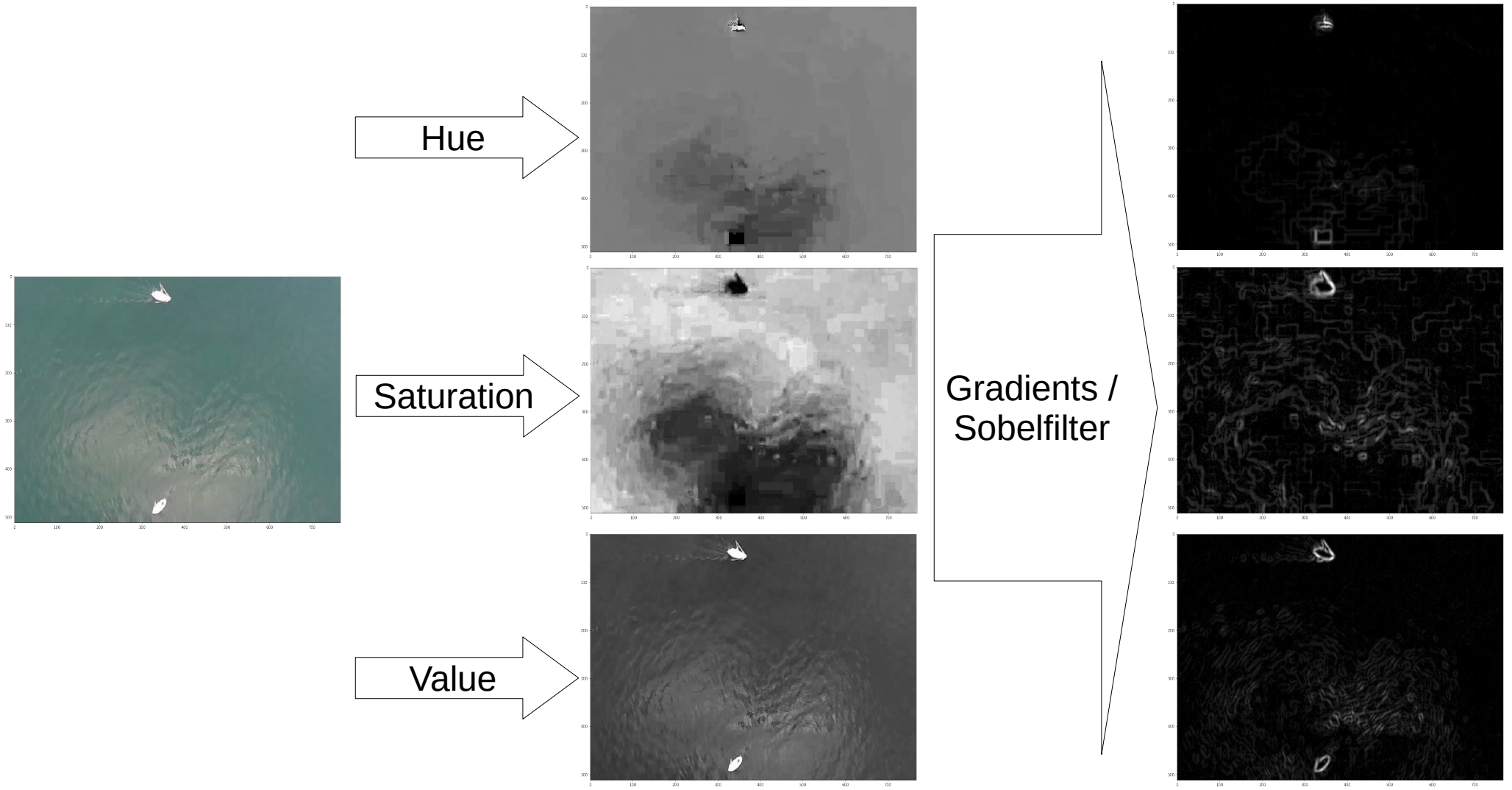


Searchwing
Computer vision

- ROI Detector

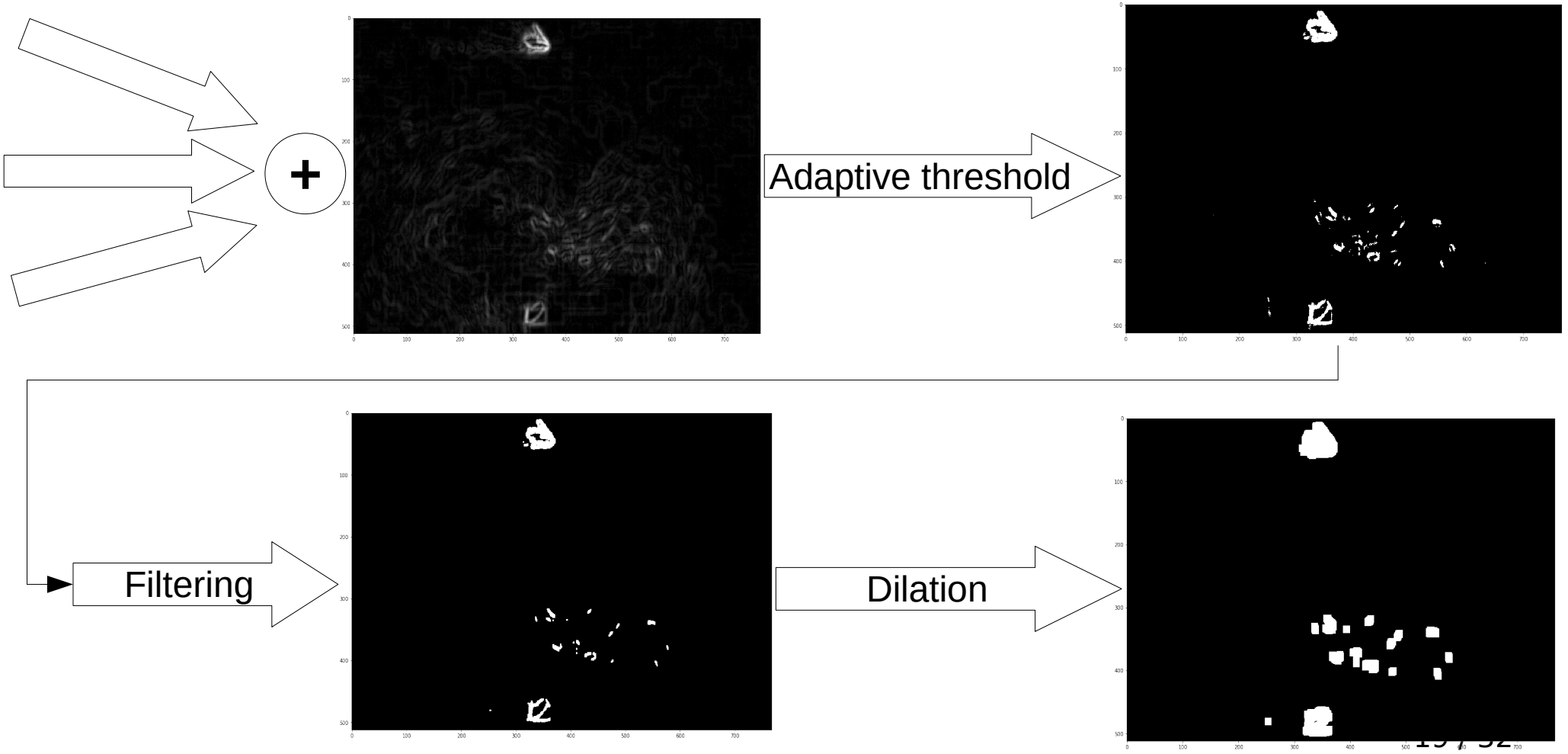
Searchwing
Computer vision

- ROI Detector



Searchwing
Computer vision

- ROI Detector



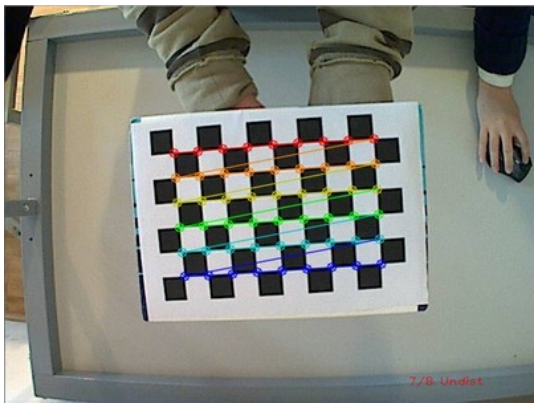
Searchwing
Computer vision

- ROI Detector

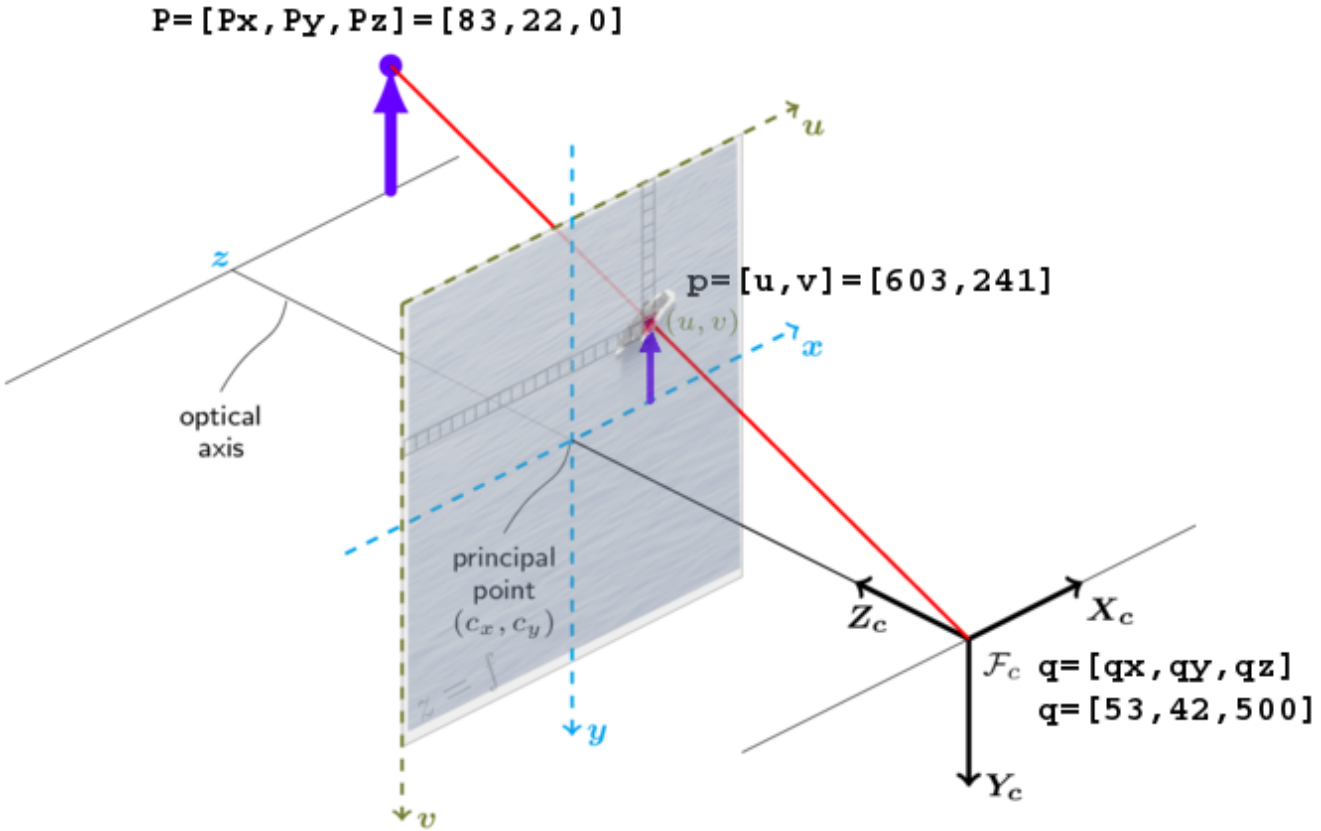
Contours

Boundingboxes

Searchwing
Computer vision

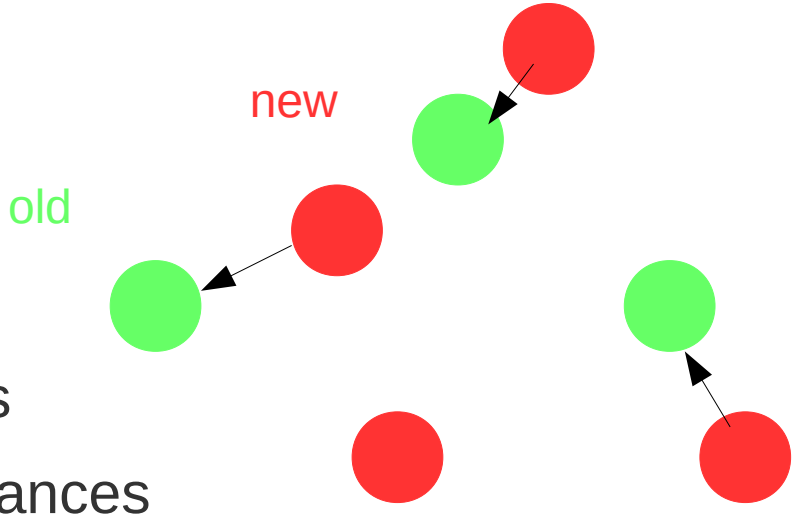


- Calculate 3D Position
  - Plane position and orientation is known
  - Using pinhole camera model
  - Parameter of the model retrieved through calibration



https://docs.opencv.org/2.4/modules/calib3d/doc/camera_calibration_and_3d_reconstruction.html

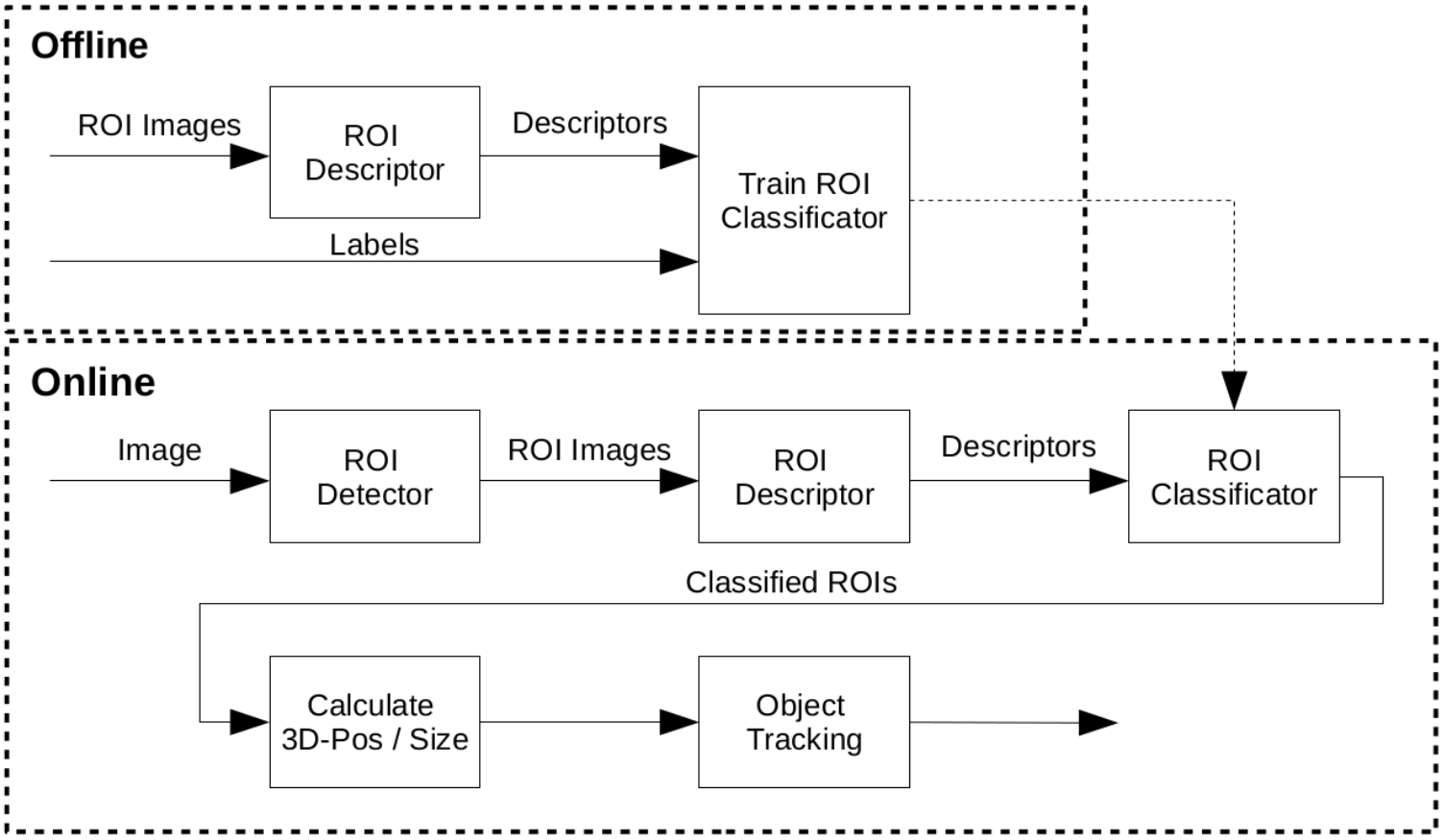
Searchwing
Computer vision



- Object tracking
  - Try to reidentify object in next frames
    - Calculate all old / new object distances
    - Hungarian-algorithm finds best fit
  - Association found: mean position as new position
  - Validation of track
    - Assumption: Nature got inconsistent appearance
    - Measure similarity of tracked object images
      - Correlation
      - Shape consistancy / Image Moments

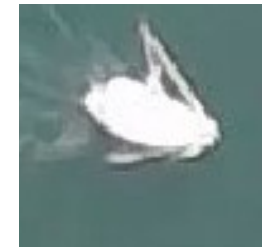
Searchwing
Computer vision

- Boatdetection by classification
  - Detect and classify ROIs as boats in the images
  - Pro: Works on single images
  - Con: Good classifier needed

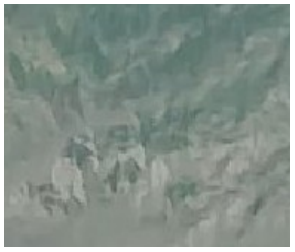


Searchwing
Computer vision

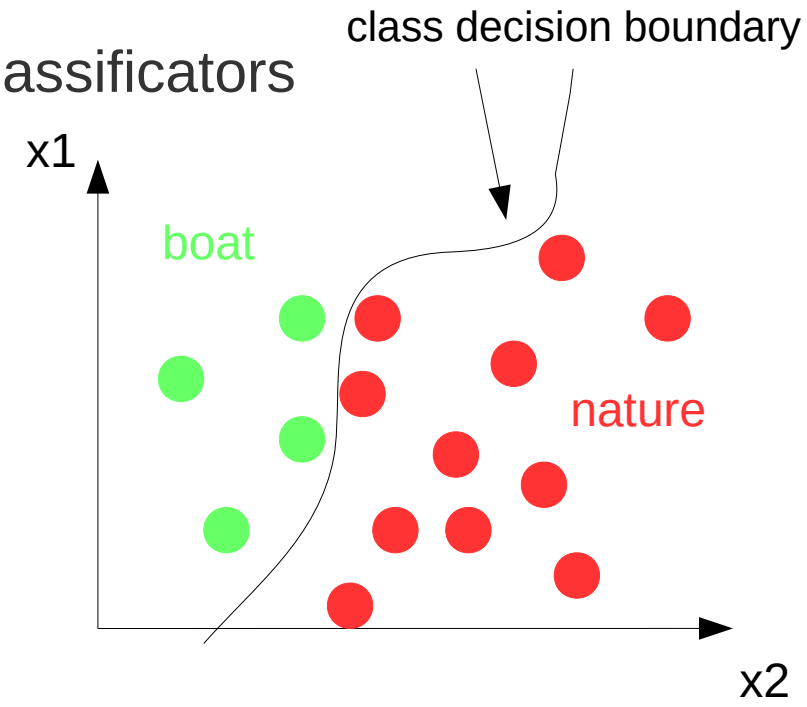
- Small excursion: Learning of image classificators



[x1, x2,..]=
[10, 44.2,...]



[x1, x2,...]=
[-5.3, 4,...]

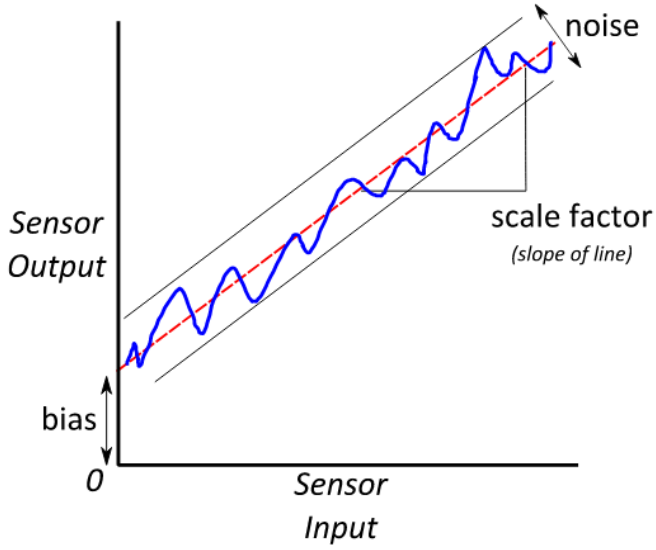


- Problem: Good training dataset needed
  - How to ensure that every possible kind of boat gets classified correctly?
  - Correct classification only possible if there is similar data / pictures in the trainingset
  - Lots of diverse data / pictures needed for training
  - Impossible to ensure that there is no false negative

Searchwing
Current progress

- Plane hardware / software
  - Autonomous land in net: https://youtu.be/T_sG5_Fi1nE

Searchwing
Current progress

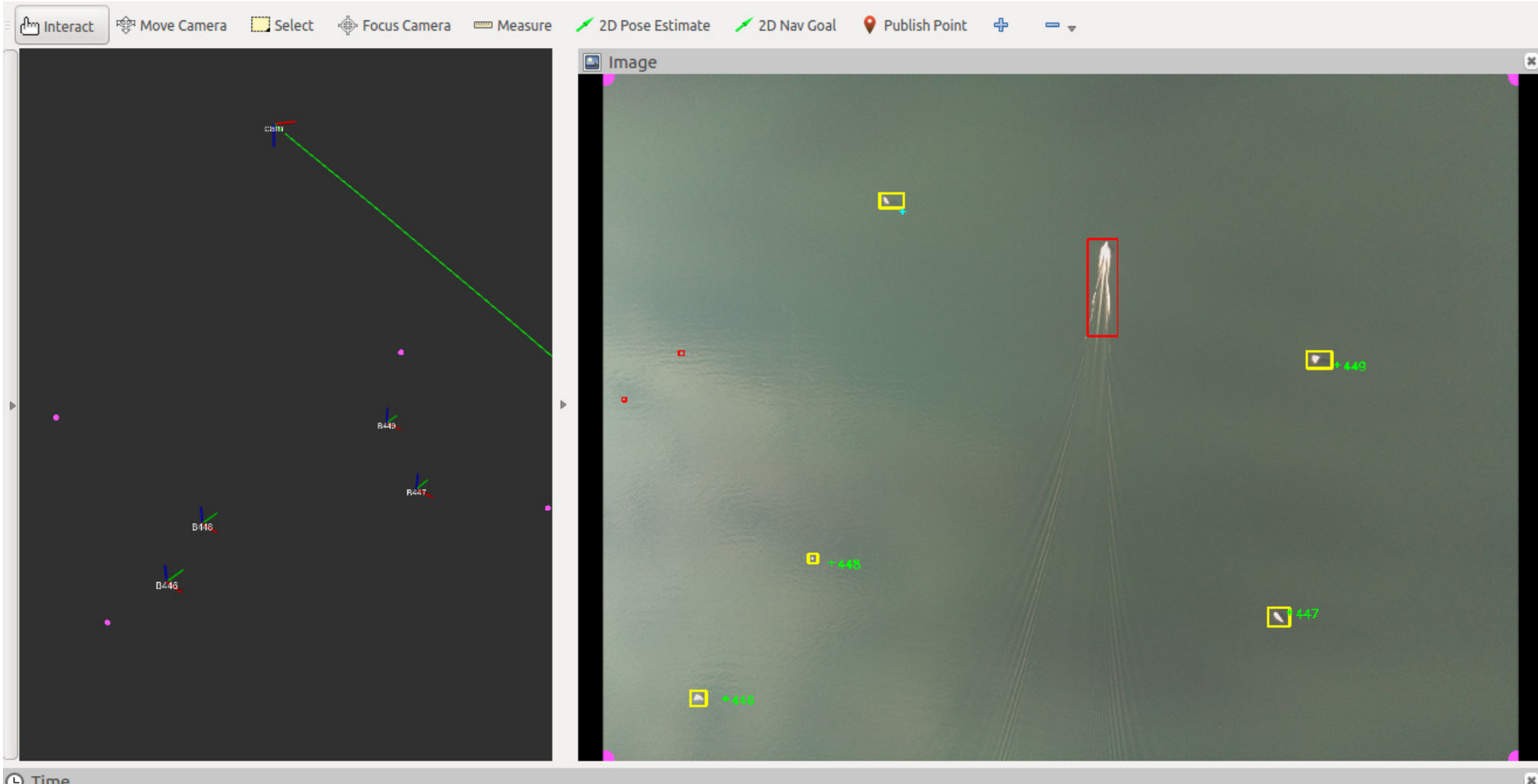


- Plane hardware / software
  - Problems to start at sea
    - Onboard calibration of sensors needed
    - Inertial sensors (IMU) calibration
      - Plane needs to stay completely still to calibrate
      - Impossible on moving ship / drone is getting sea sick
    - Compass calibration
      - Difficult due to magnetic field noise from ship (metal!)
  - Problems to land at sea
    - Strong winds on sea
    - Difficult to hit landing net
    - Land in water / waterproove drone

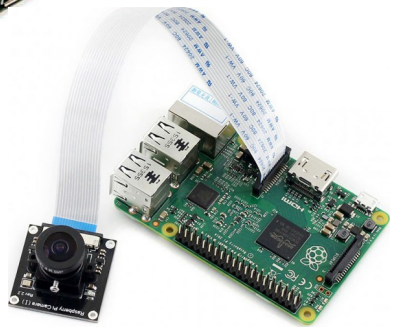
https://www.novatel.com/assets/Documents/Bulletins/APN064.pdf

Searchwing
Current progress

- Computer vision
  - https://github.com/julled/searchwing

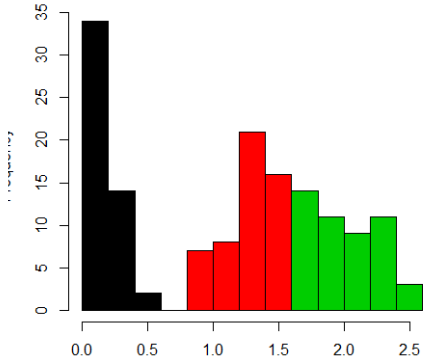


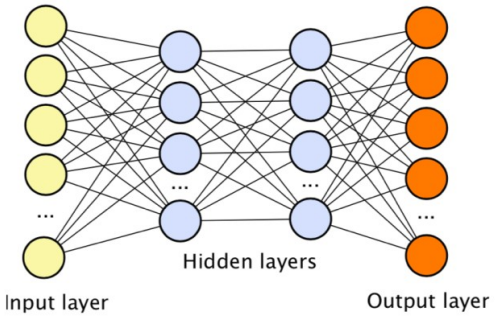
Searchwing
Current work packages



- Computer vision
  - Deploy code to embedded computer
    - Find / benchmark cheap embedded boards
    - Implementation of algorithms in C++
  - Image classification for validation
    - No blackbox algorithm should be used
    - Understandable features
  - Test different concepts
    - Deep Learning based image classifiers
    - Use of open available satellite data

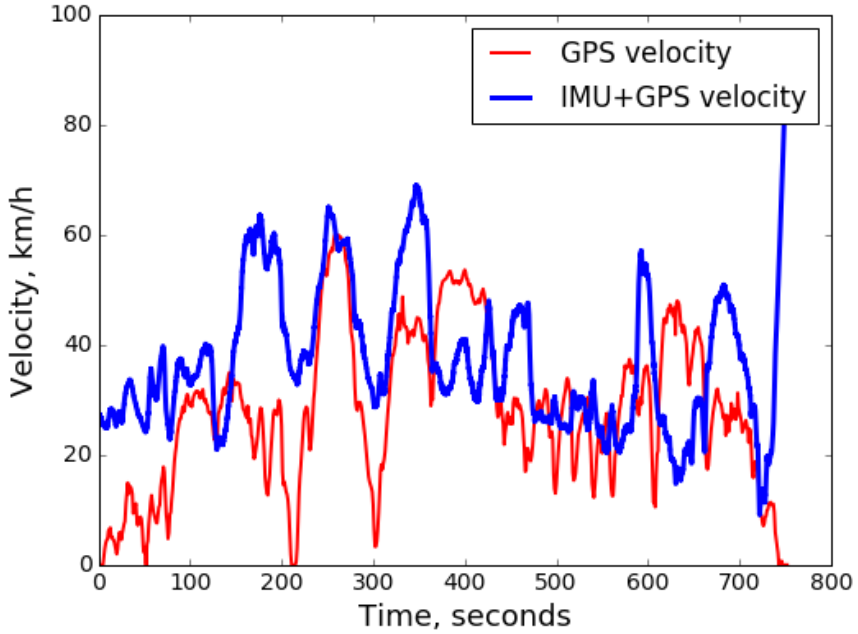
[x1, x2, x3, …]



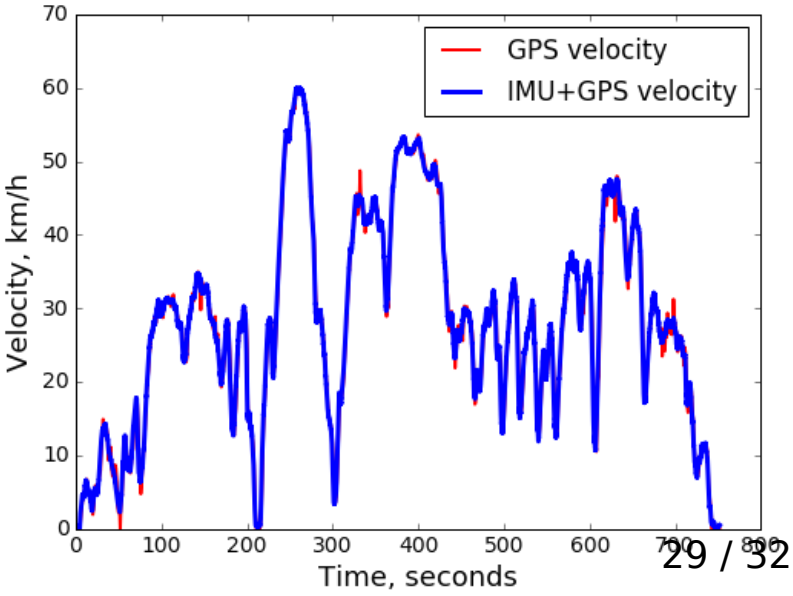


Searchwing
Current work packages

- Plane hardware / software
  - Research in calibration of IMU / accelerometer / gyro on ship
    - Calibration against high accurate reference onboard IMU
    - Calibration / fusion of reference IMU against GPS for longtime stability
    - Calibration against static known camera by using horizon



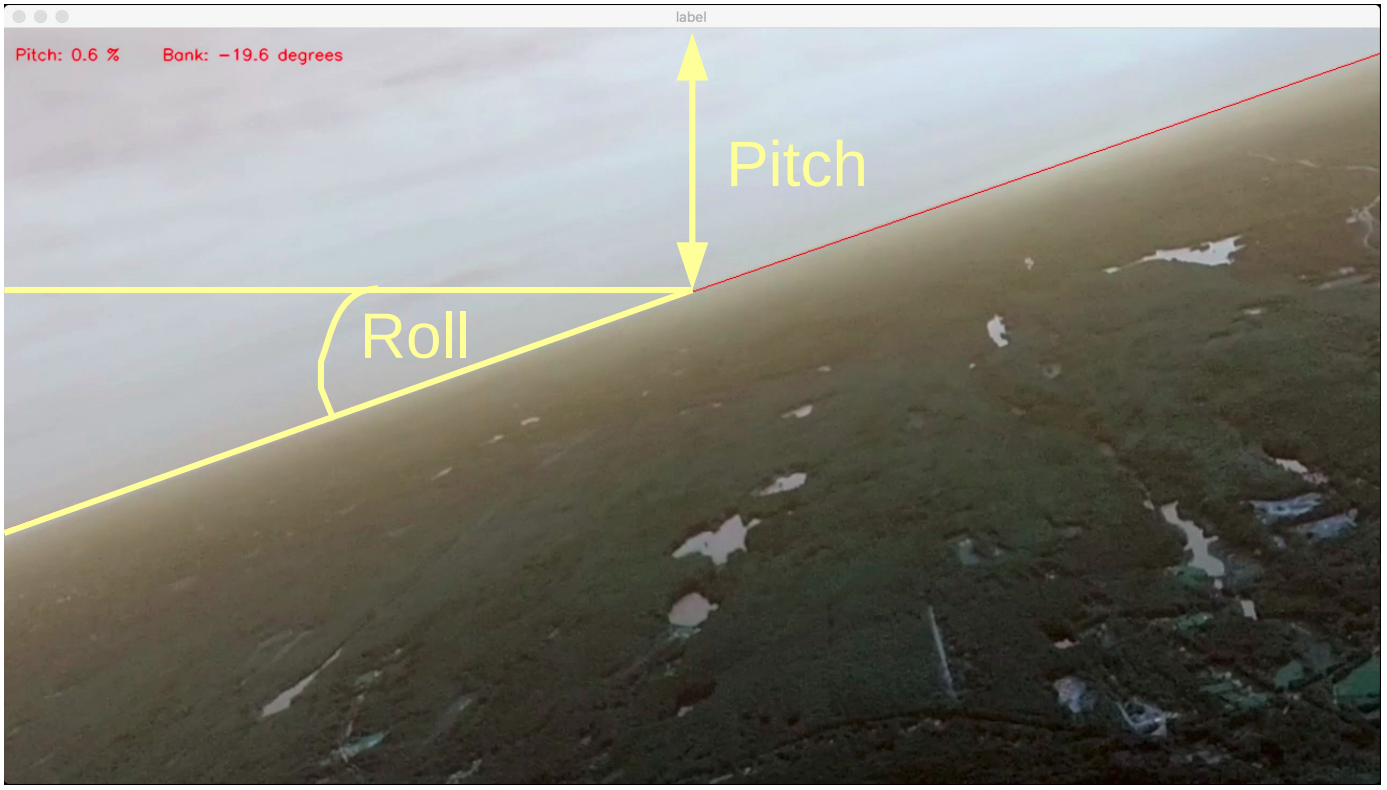
Calibration



https://github.com/waiwnf/pilotguru

Searchwing
Current work packages

- Plane hardware / software
  - Flying by using camera
    - Estimate roll and pitch of plane in image
    - Problems: Weather dependent flying, second camera



Searchwing
Free open source frameworks

- Plane Software / Hardware
  - Plane control software: ardupilot / px4
  - Handling of datastreams: ROS
- Computer Vision
  - Basic image operations: OpenCV3, arm compute library?
  - Interprocess comm., 3D-transformation, visualization: ROS
  - Lots of python packages: numpy, pymap3d, ...

ARDUPILOT

px4 autopilot

OpenCV

Thank you!
Questions?

- Call for participation
  - Plane - computer vision
    - Deploy code to embedded computer (find board, C++ impl.)
    - Image classification for validation
    - Test different concepts (Deep learning / satellites)
  - Plane - hardware / software
    - Research in calibration of IMU / accelerometer / gyro on ship
    - Flying by using camera

mail: petrosilius@posteo.de