Automatic View Finding for Drone Photography based on Image Aesthetic Evaluation

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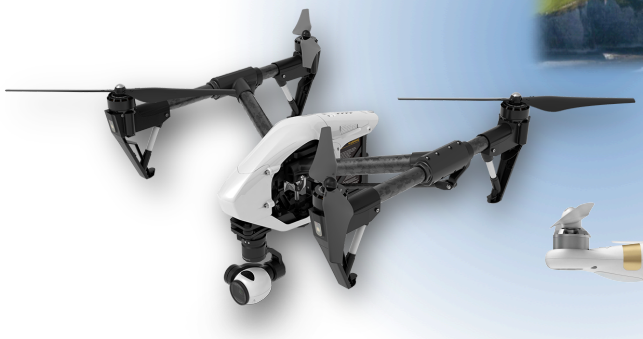
Motivation

Smart drones

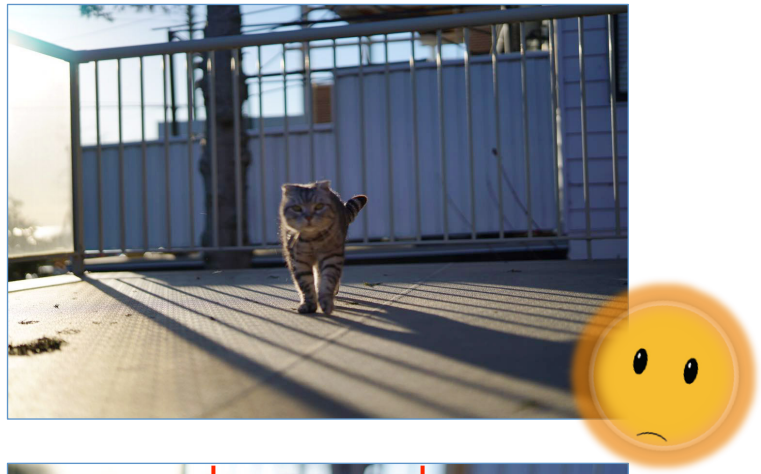


Remote controllers

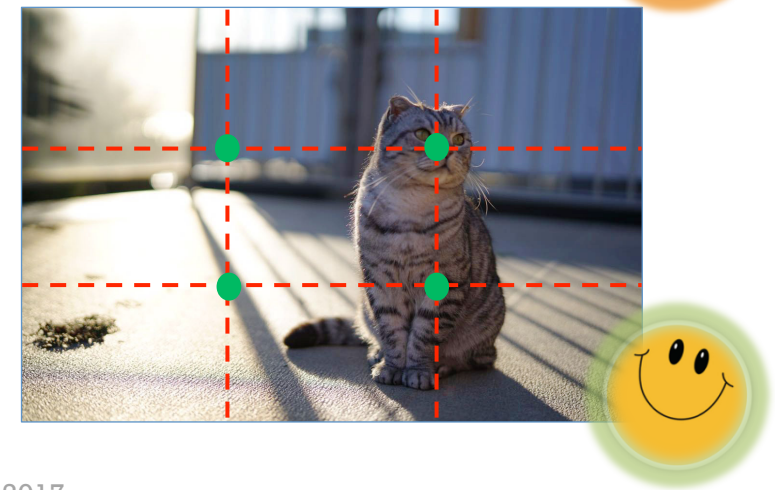
- Aerial photography
- Surveillance
- Intelligent tracking

Motivation

- Drone photography

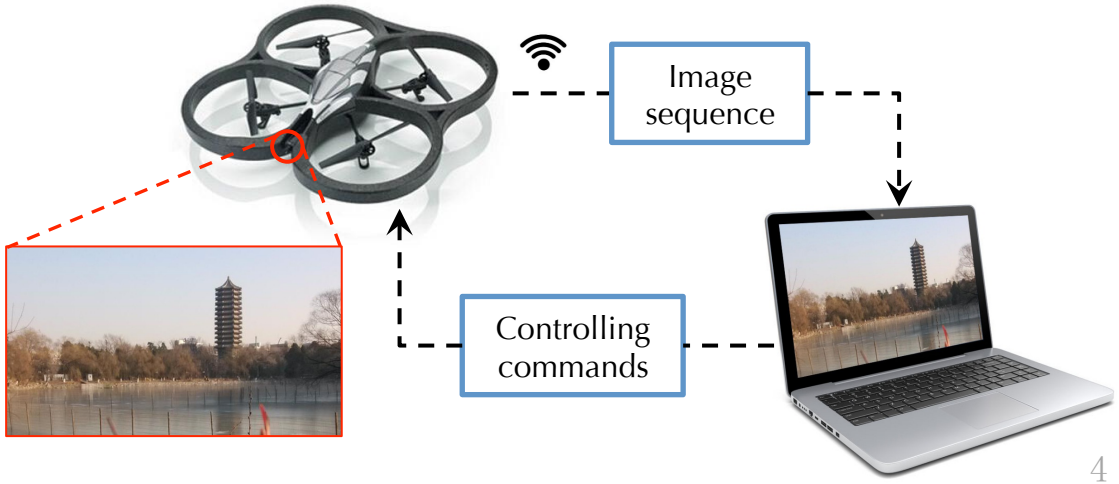


- What is a ***good*** photo?
  - Visually pleasant
  - Image aesthetics



Motivation

- Automatic view finding
  - Image aesthetic evaluation
    - Widely accepted guidelines
  - Autonomous flight of drones
    - Drone navigation according to the aesthetic score
    - Finding the optimal view



Related Work

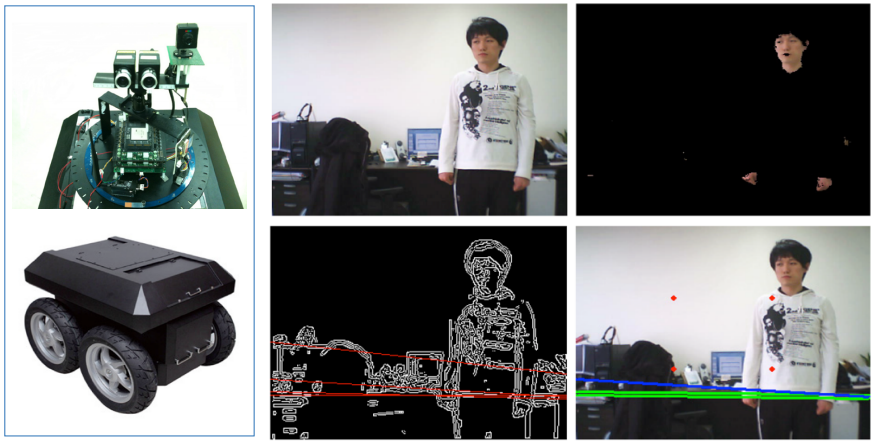
- Obstacle avoidance / Autonomous navigation
  - Using active sensors
    [Benet et al., 2002; Bachrach et al., 2011]
    - Laser range finders / sonar / infrared detectors
    - Not suitable for unstructured environments
  - Vision-based methods
    [Soundararaj et al., 2009; Bills et al., 2011; Lenz et al., 2012]
    - Color image / depth image
    - Prior knowledge needed
    - Complex 3D reconstruction

Obstacle classification and avoidance
[Lenz et al., 2012]

Related Work

- Automatic photography
  - Autonomous Robot Photographing
    [Byers et al., 2003; Kim et al., 2010]
    - Subject detection: human voice / skin color
    - Remote path planning / motion control
    - No general rules for photography

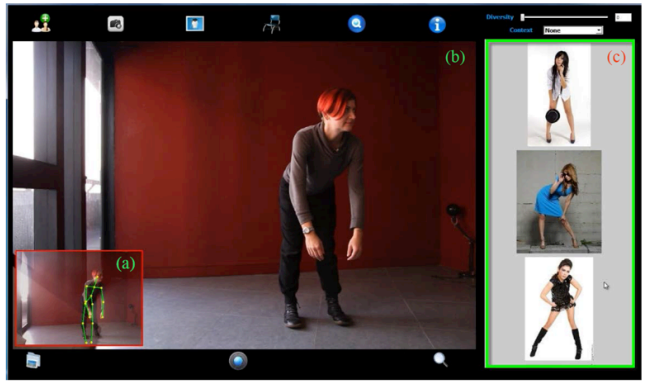
[Byers et al., 2003]



[Kim et al., 2010]

Related Work

- Automatic photography
  - Autonomous Robot Photographing
    [Byers et al., 2003; Kim et al., 2010]
    - Subject detection: human voice / skin color
    - Remote path planning / motion control
    - No general rules for photography
  - Semi-automatic photography
    [Fu et al., 2013]
    - Data-driven pose suggestion
    - A large collection of reference poses
    - Subject makes refinement to match the selected pose



[Fu et al., 2013]

Related Work

- Image quality assessment
  - High level semantic features [Ke et al. 2006; Luo and Tang 2008]
  - Image composition rules [Krages, 2005; Yao et al., 2012]
- Image composition optimization
  - Image cropping / warping / resizing
  - Post-processing / Image distortion

Image Cropping
[Liu et al., 2010; Ni et al., 2013]

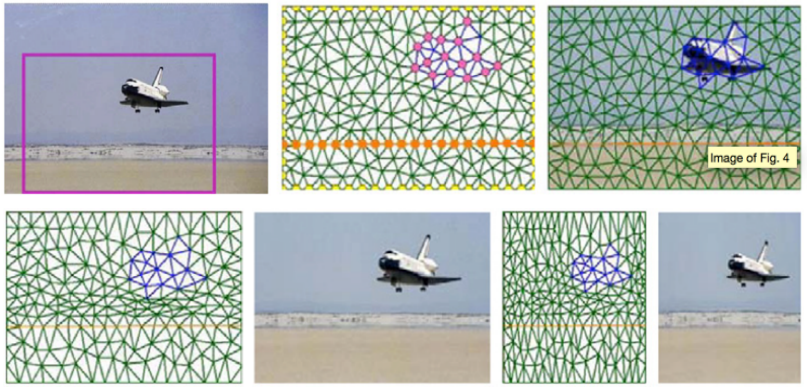
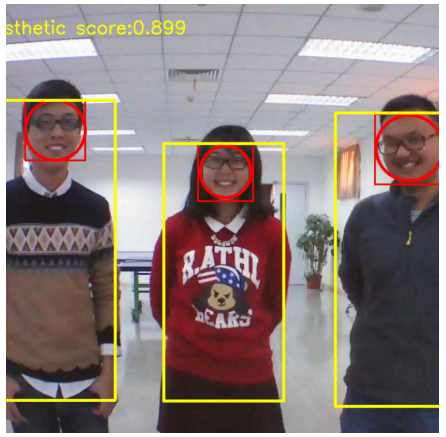
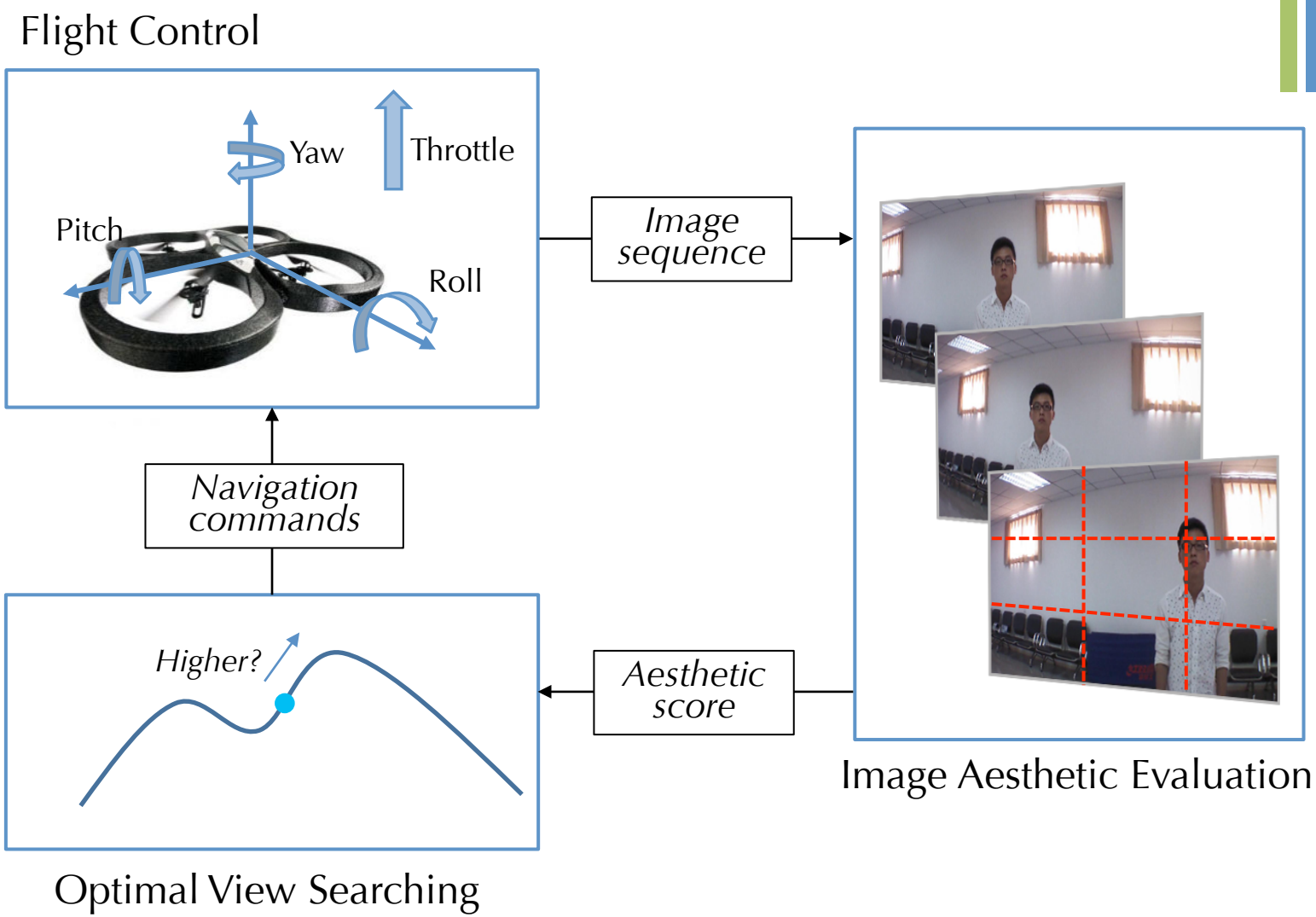


Image Warping
[Jin et al., 2012]

Automatic View Finding based on Image Aesthetic Evaluation

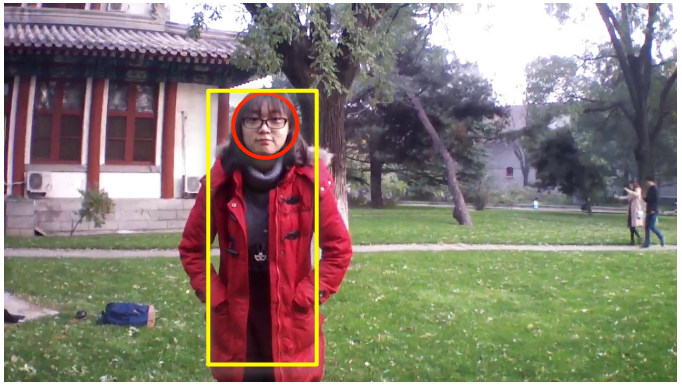


Method Overview



Subject Detection

- Photographic subject
  - Automatic detection
  - Human Portraits: face & body
    - Face detection based on Haar features [Viola and Jones, 2004]
- Image features
  - Prominent lines for aesthetic evaluation
    - Line segment detection based on Hough transform [Duda and Hart, 1972]



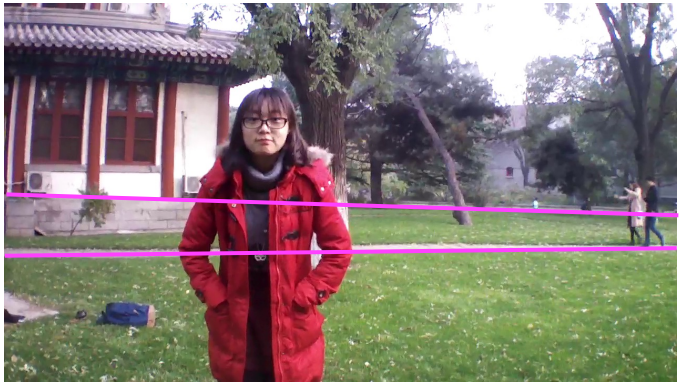
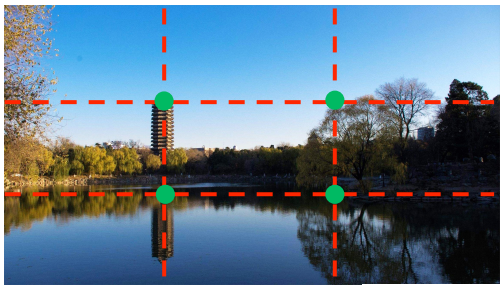


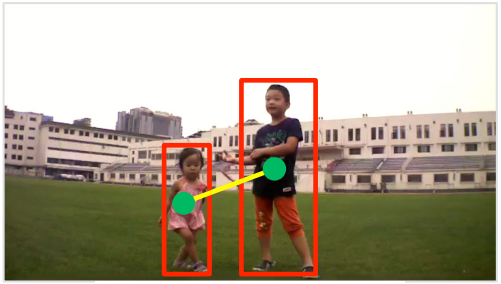
Image Aesthetic Evaluation

- Image composition guidelines
  - General guidelines for photographers
  - Quantization of the guidelines [Liu et al., 2010]



Rule of thirds

$$E_{RT} = \lambda_{point} \frac{1}{\sum_i M(S_i)} \sum_i M(S_i)\, e^{-\frac{D^2(S_i)}{2\sigma_1}} + \lambda_{line} \frac{1}{\sum_i I(L_i)} \sum_i I(L_i)\, e^{-\frac{D^2(L_i)}{2\sigma_2}}$$



Visual balance

Proper region size

$$E_{VB} = e^{-\frac{D^2(S_w, C)}{2\sigma_3}}$$

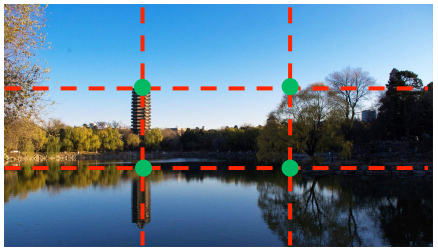
$$E_{RS} = \sum_i max_{j=1,2,3}\, e^{-\frac{(r(S_i)-r_j)^2}{2\tau_j}}$$

Image Aesthetic Evaluation

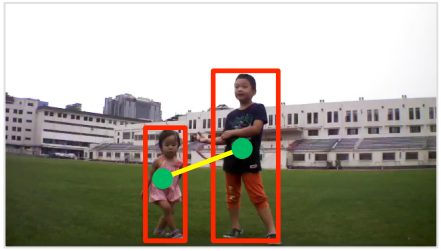
- Image aesthetic score

$$E = \frac{w_1 E_{RT} + w_2 E_{VB} + w_3 E_{RS}}{w_1 + w_2 + w_3}$$

  - Automatic online aesthetic evaluation
  - Guidance for searching the optimal view
    - Maximum of aesthetic score *E*



Rule of thirds

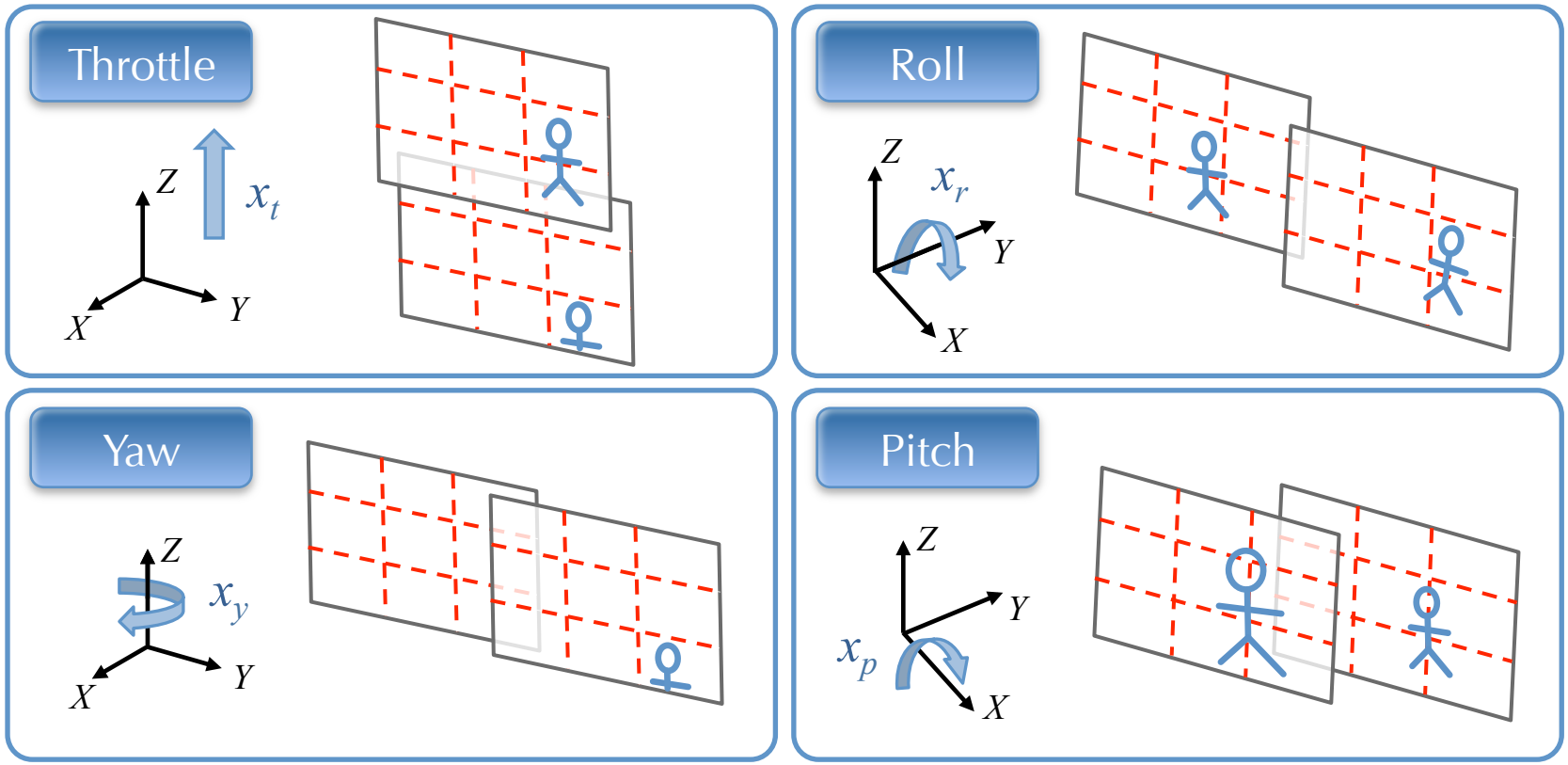


Visual balance

Proper region size

Optimal View Searching

- The four flying status of drone
  - Movement $x_i, \quad i \in \{t, r, y, p\}$

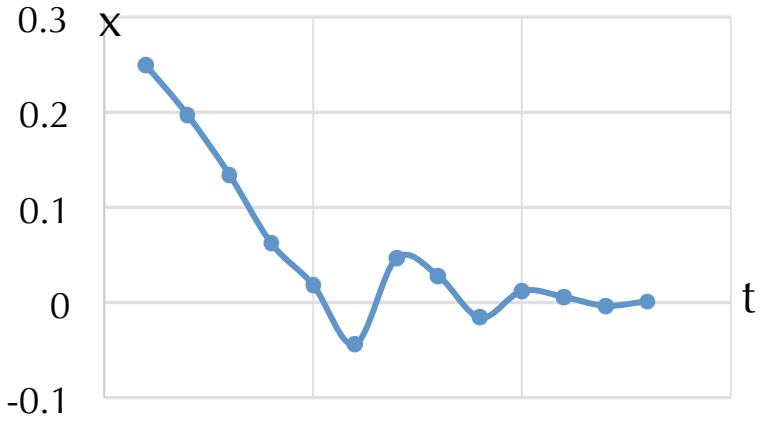


Optimal View Searching

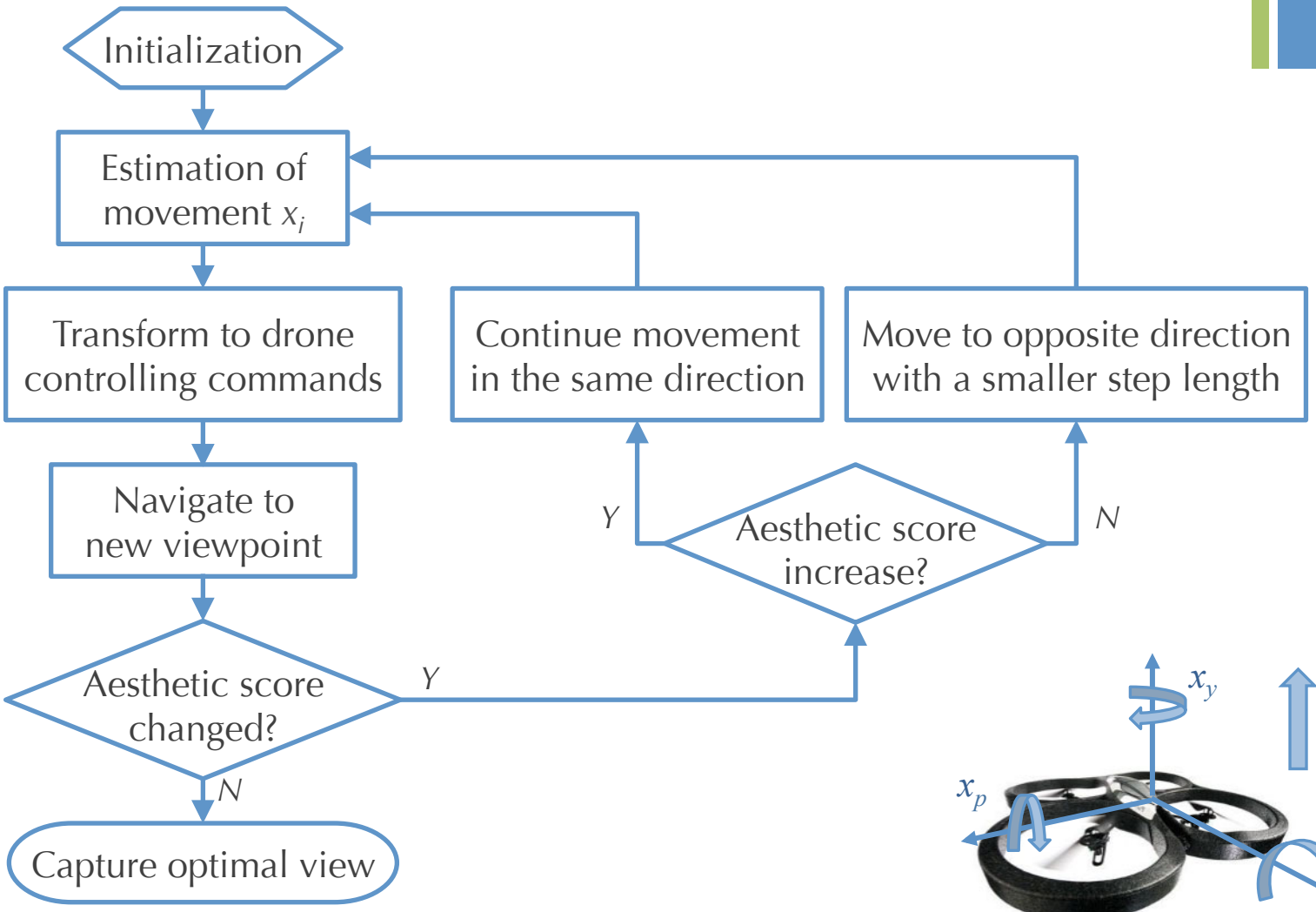
- Image aesthetic score
  - An implicit function of drone flying status
- Target function for automatic view finding

$$\max E = f(x_t, x_r, x_y, x_p)$$

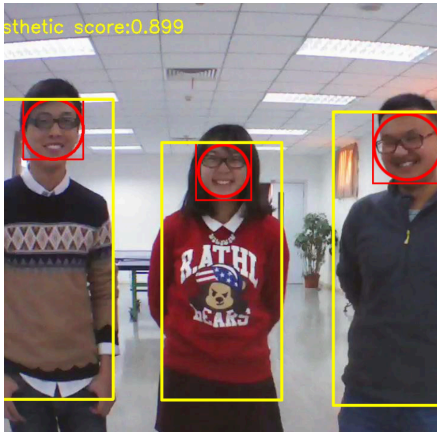
  - Optimization
    - Multi-dimensional solution space
    - Downhill simplex method [Press et al., 1992]
    - Heuristically searching for the optimal view



Optimal View Searching

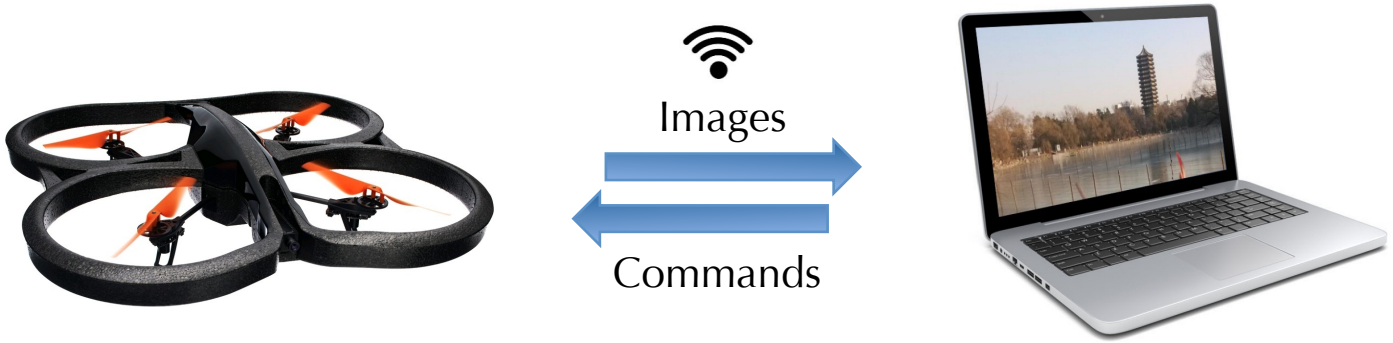


Experimental Results



Experimental Results

- Implementation



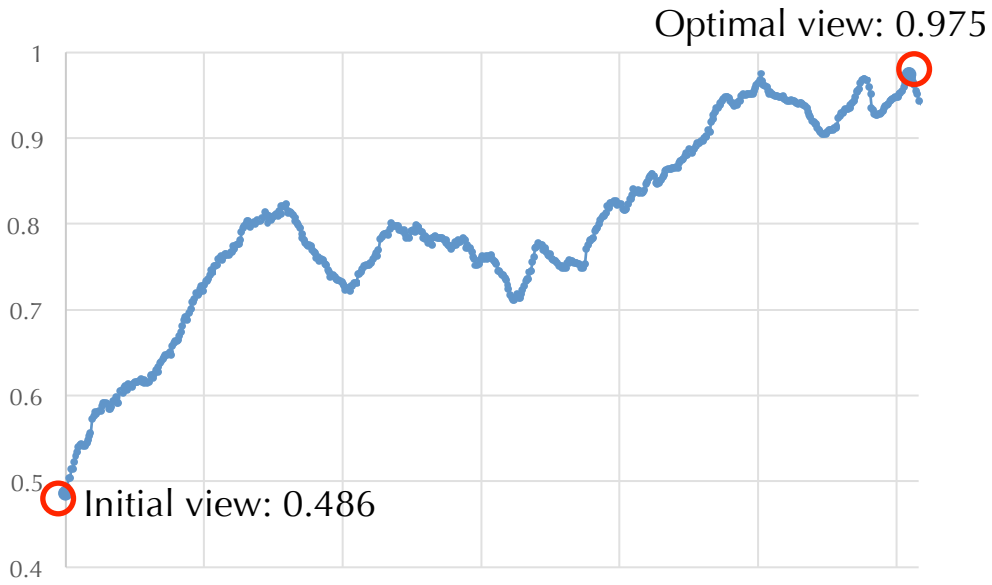
- Parrot AR. Drone 2.0
  - Camera resolution: 1280x720
  - Sonar height sensor
  - Onboard computer
- Host PC
  - Common laptop
  - 2.10GHz Pentium dual core
  - 1GB RAM
  - Linux OS of Ubuntu 14.04

Experimental Results

- Target-locating test
  - Placing the target in the center of the image

Initial

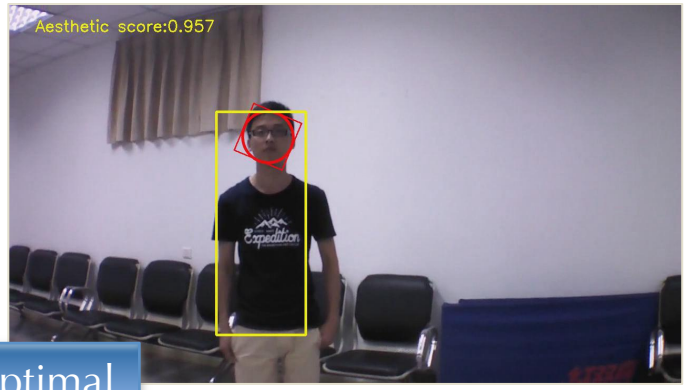
optimal



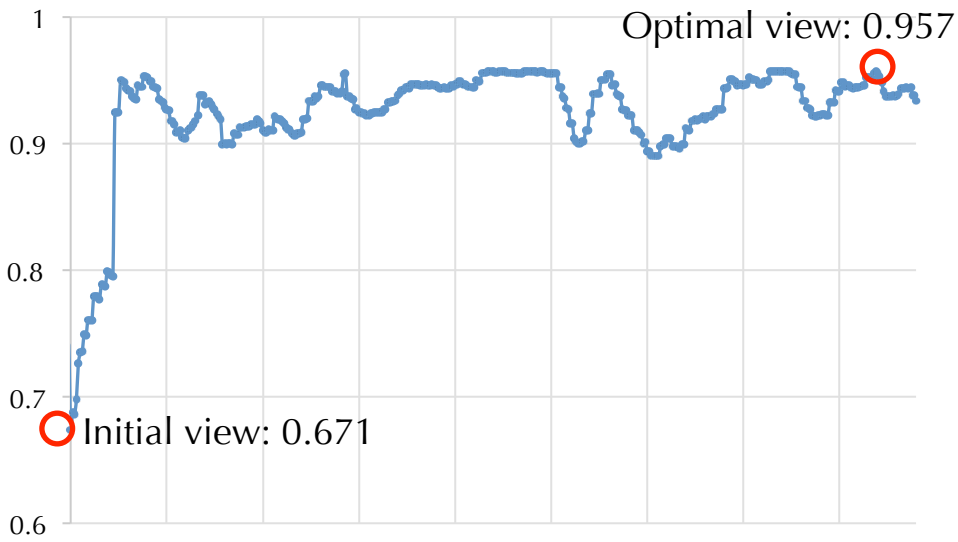
Experimental Results

- Single-subject Photographing
  - Indoor environment

Initial



optimal



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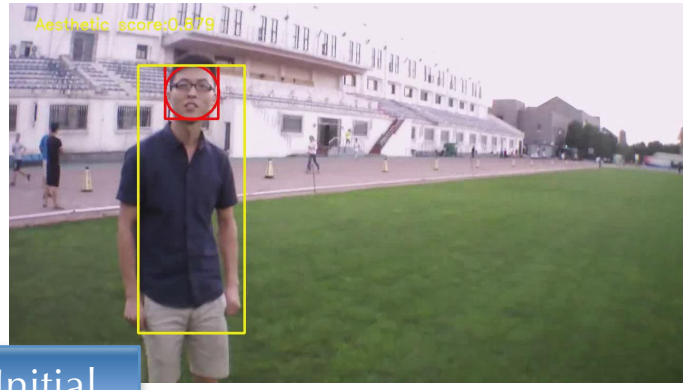
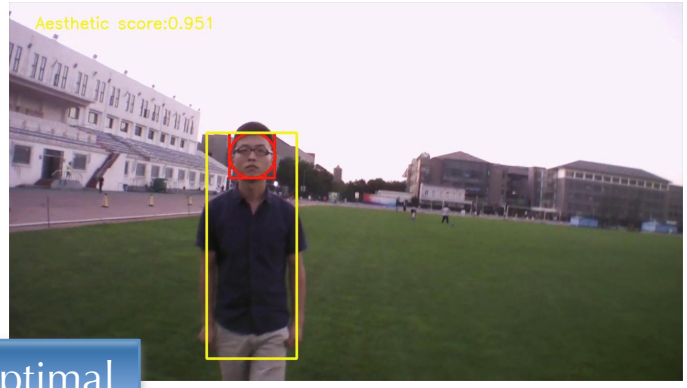
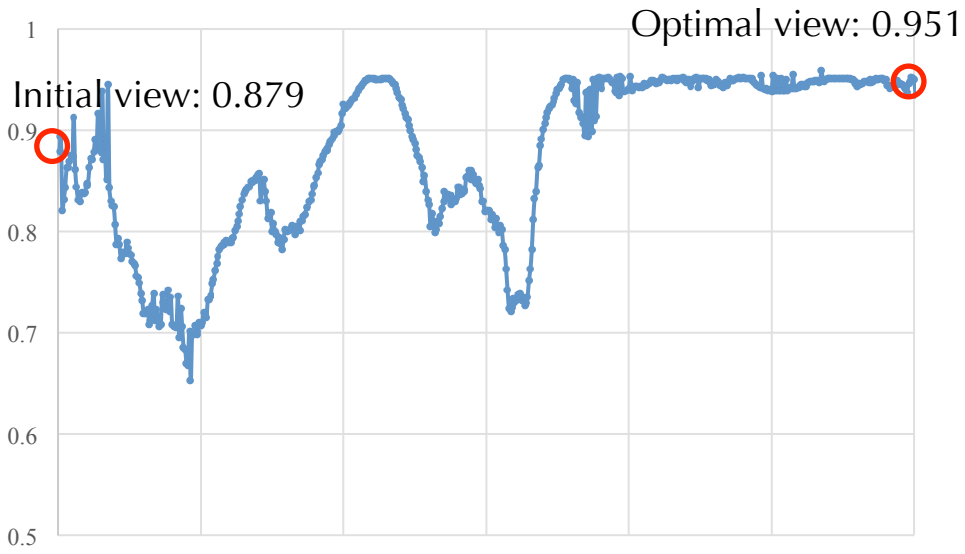


Initial



optimal



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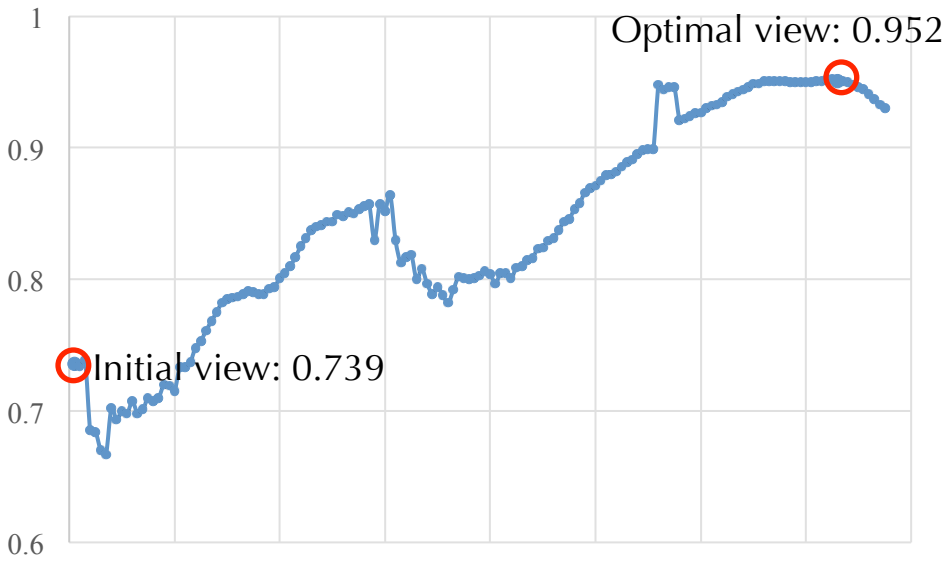
optimal



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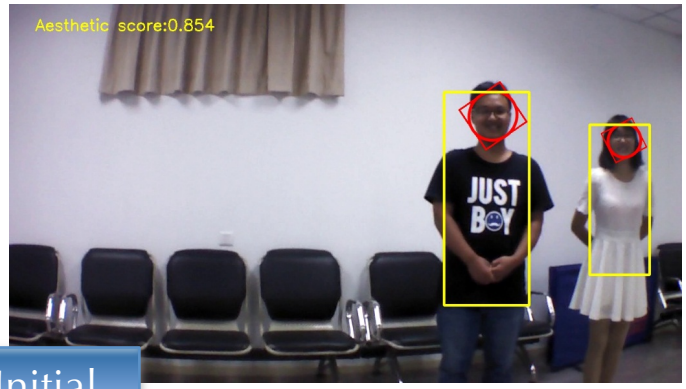

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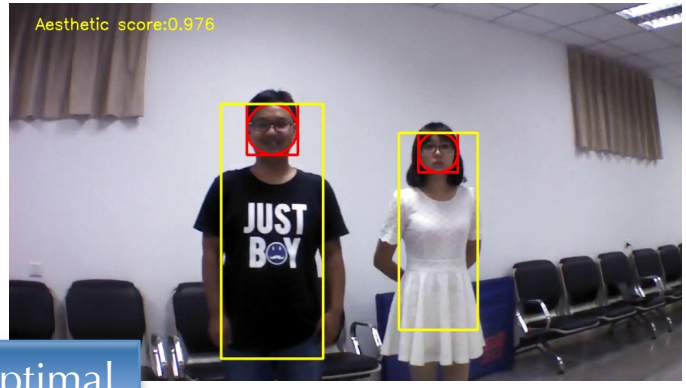
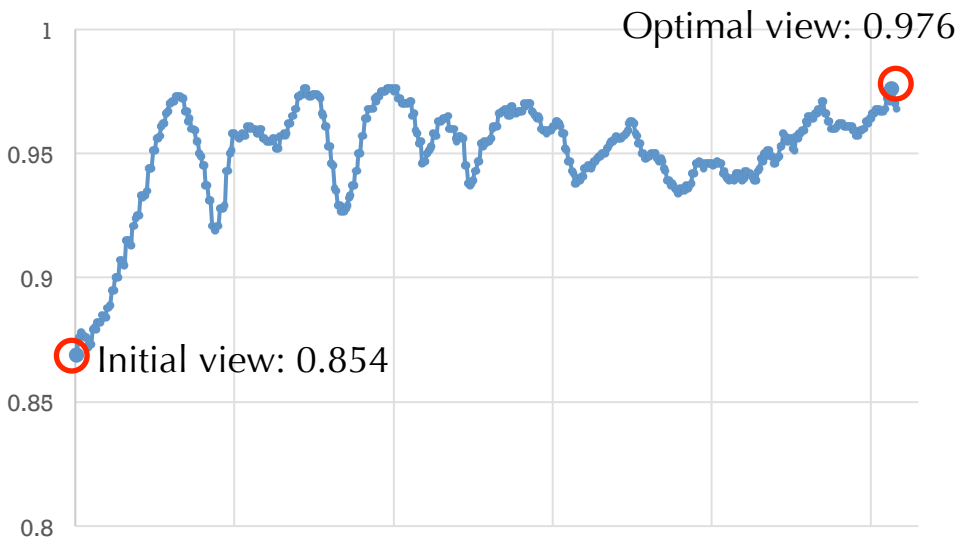


optimal



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  - Outdoor environment

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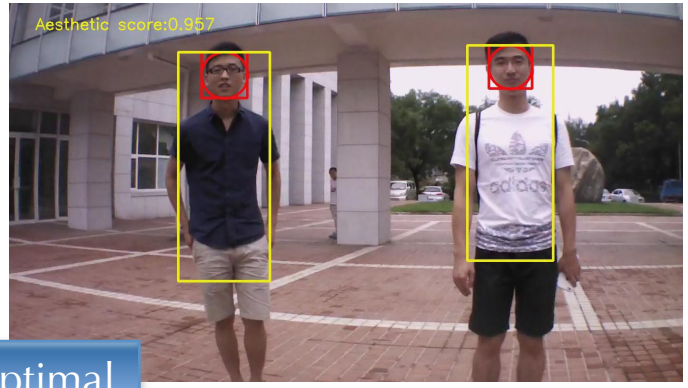

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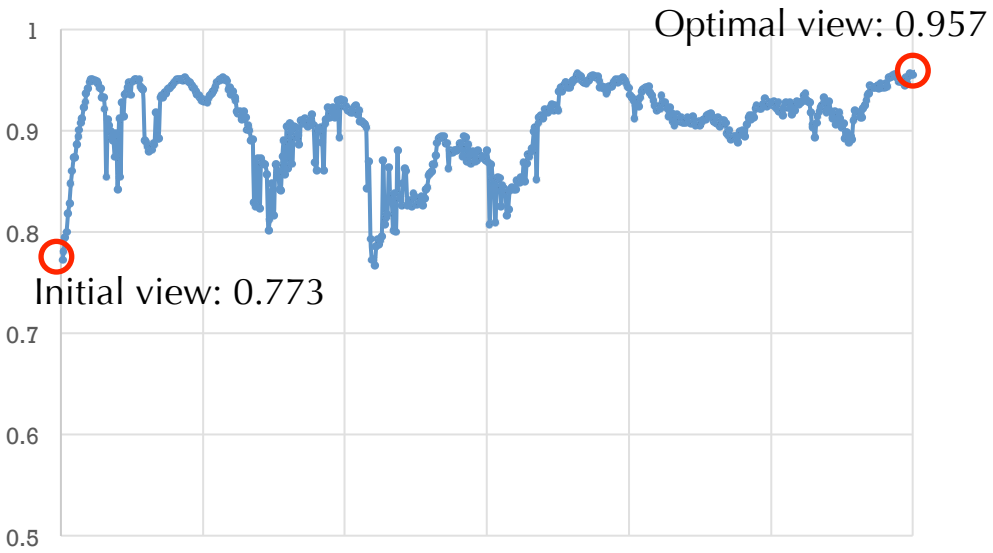
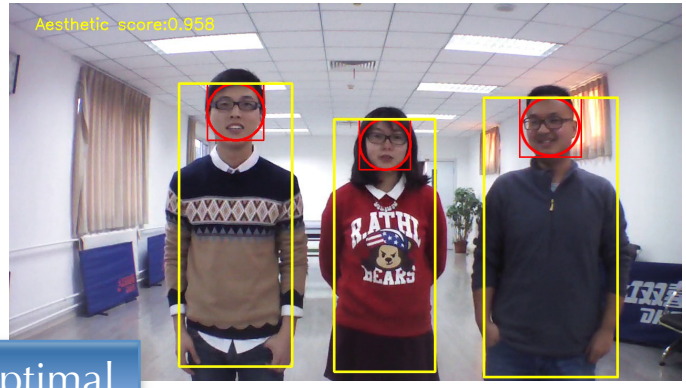


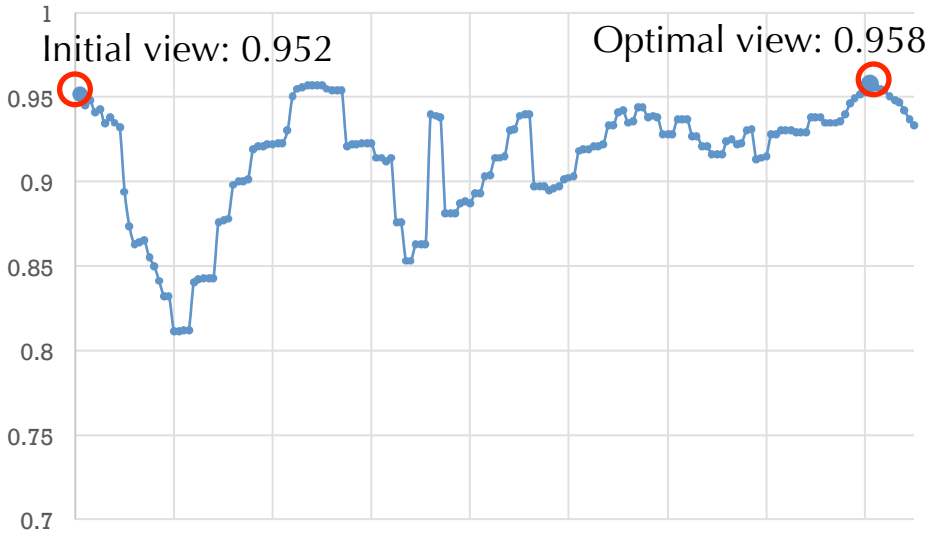
Experimental Results

- Multi-subject Photographing
  - More subjects…

Initial



optimal

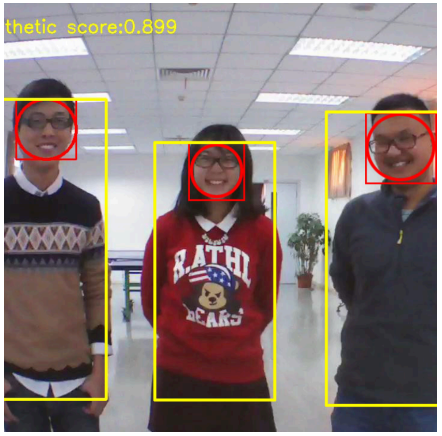


Summary

- Automatic view finding for drone photography
  - Image aesthetic evaluation
    - Satisfying basic composition guidelines
  - Heuristic search for the optimal view
    - Autonomous navigation of drone
- Future work
  - More stable and intelligent subject detection
    - More rules and clues
  - Different types of photographic subjects

GRAPP 2017, Feb. 27, 2017

Thank you!



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