Use of binocular computer vision for camera focusing

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The aim of the project was to develop a software for automatic camera focus control with the use of binocular computer vision algorithms.
Relevance

- Modern approaches to the camera focusing problem are not flawless and are ineffective in certain conditions.
- It is possible to create a reliable mathematical model of scene with the use of binocular computer vision algorithms.
- Applications of binocular computer vision to the problem of camera focusing are not yet known.
Components of the system

- Calibration images
- Preliminary processing
- Calibration subsystem
- Image analysis subsystem
- Camera focus control
- Calibration and rectification calculation
- Detection
- Stereo pairs processing
Preparatory step

Get images from cameras

Get pattern configuration info

Detect pattern on the images

Pattern was detected on insufficient number of images

Show error notification

else

Calibrate cameras

Calculate rectification parameters
Camera calibration
Main step

1. Get camera calibration
2. Get images from cameras
3. Calculate rectification
4. Find stereo pair
5. Calculate distance
6. Change camera focusing
7. Detect object
8. Get information about cameras and detection object
9. Object is not detected?
   - Yes: Finish command was sent
   - No: Get information about cameras and detection object
10. Object detected?
    - Yes: Calculate distance
    - No: Change camera focusing
11. Calculate distance
12. Change camera focusing
13. Detect object
14. Get information about cameras and detection object
15. Object is not detected?
   - Yes: Finish command was sent
   - No: Get information about cameras and detection object
16. Finish command was sent

Diagram:

- Start
- Get camera calibration
- Get images from cameras
- Calculate rectification
- Find stereo pair
- Calculate distance
- Change camera focusing
- Detect object
- Get information about cameras and detection object
- Object is not detected?
  - Yes: Finish command was sent
  - No: Get information about cameras and detection object
- Finish command was sent
- End
Rectification
Rectification
Local stereo measure SAD

For two images $A$ and $B$ of the same size $n \times m$:

$$\sum_{i=0}^{n} \sum_{j=0}^{m} |A_{ij} - B_{ij}|.$$

Function of an image that returns $x$ coordinate of it’s stereopair:

$$f(X) = \arg \min_{x \in [x_0, n]} \sum_{i=0}^{n'} \sum_{j=0}^{m'} |l_{x+i, y_0+j}^2 - X_{ij}|,$$
Found stereopair

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Distance calculation

\[ Z = f \cdot T - (x^l - x^r) - (c_x^{\text{left}} - c_x^{\text{right}}). \]
Optimal focusing function

\[ f(x) = -1.341 \cdot 10^{-10} x^7 - 8.6 \cdot 10^{-8} x^6 + 2.29 \cdot 10^{-5} x^5 - 0.002092 x^4 + \\
+ 0.09166 x^3 - 2.012 x^2 + 19.05 x - 1.874 \]
Frame quality estimation

Laplace operator is widely used for edge detection at image processing.

If given blurred image, Laplace operator can’t detect fine edges since intensitivity changes smoothly across the image.
Experiment results

![Graph showing relative number of frames vs. average intensity for Software developed and Autofocus.](image-url)
Aux slide 1: disparity