Technische Universität München
Fakultät für Informatik
Prof. Gudrun Klinker, Ph.D.
Adnane Jadid, Christian Eichhorn, David A. Plecher

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Exercise Sheet 2
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Introduction to Augmented Reality

Exercise 4 (P,H) Thresholding

In order to detect monochrome markers in the camera image, we first convert the color image into a white-and-black image.

(a) First, convert the camera image to a grey image by `cv::cvtColor`, as the thresholding algorithms work only with grey images. `cv::cvtColor` requires a conversion type–`CV_BGR2GRAY`, indicating from color to gray scale.

(b) Two thresholding functions exist: `cv::threshold` and `cv::AdaptiveThreshold`. Try both methods and show the result in a new window. For `cv::threshold`, create a slider using `cv::createTrackbar` to easily change the thresholding parameter.

(c) Experiment with the parameters. Choose parameters such that the markers are clearly visible under all lighting conditions and viewing angles. They should have a continuous frame which does not merge with the environment.

(d) Briefly describe the advantages and drawbacks of both tresholding algorithms.

Exercise 5 (P,H) Finding Rectangles

In the last exercise, you have generated a thresholded black-and-white image.

(a) Expand your program using the functions `cvFindContours` and `cvApproxPoly` to first extract object boundaries and then approximate these with straight line segments.
Hint: for the second-to-last parameter of `cvApproxPoly`, try a value of
`cvContourPerimeter(contours) * 0.02`.
Note: `cvFindContours` uses the OpenCV heap. Use `cvCreateMemStorage`, `cvClearMemStorage` and `cvReleaseMemStorage` to manage it.

(b) Traverse all found contours and determine each bounding box using `cv::boundingRect`. Skip all polygons with more or less than 4 corners or too small bounding boxes (experiment with constraint values). Use `cv::cvarrToMat` for converting (CvSeq*) to (cv::Mat).

(c) Mark the rectangles you have found with red lines using `cv::polylines`. Do this in the original camera image and display it afterwards.

(d) Subdivide each edge of the rectangles into 7 parts of equal length and draw a small circle around each of the dividing points. You will need these in the next exercise.

<u>Exercise 6</u> (H) Cross Product

(a) What is the definition of a Cross Product of two vectors?

$\vec{a} \times \vec{b} = \vec{n}$
The cross product $\vec{a} \times \vec{b}$ is defined as $\vec{n}$ that is orthogonal to $\vec{a}$ and $\vec{b}$.
$\|\vec{a} \times \vec{b}\| = \|\vec{a}\|\|\vec{b}\| \sin \xi$, where ξ is the angle between $\vec{a}$ and $\vec{b}$.

(b) Calculate the Cross Product for

$$\vec{a} = \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix}; \vec{b} = \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}$$

$$\vec{a} \times \vec{b} = \vec{n} = \begin{pmatrix} 1 \\ -1 \\ -1 \end{pmatrix}$$

(c) Show that the plane - containing $\vec{a}$ and $\vec{b}$ - and $\vec{n}$ are orthogonal by using scalar and cross product.

$\vec{a} \cdot (\vec{a} \times \vec{b}) = 0 \Leftrightarrow \cos 90° = 0;$
$\vec{b} \cdot (\vec{a} \times \vec{b}) = 0 \Leftrightarrow \cos 90° = 0;$