Melioration of color calibration, goal detection and self-localization systems of NAO humanoid robots

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Introduction

This poster presents the work regarding the development process of an autonomous robot soccer software. The work covers color calibration, object detection and self-localization topics. A novel YUV color space based method for the automation of color calibration is proposed. Changes made to the goal detection module and motivation behind them are described. Finally, the localization system enhancement technique is proposed and explained.

Automatic Color Calibration

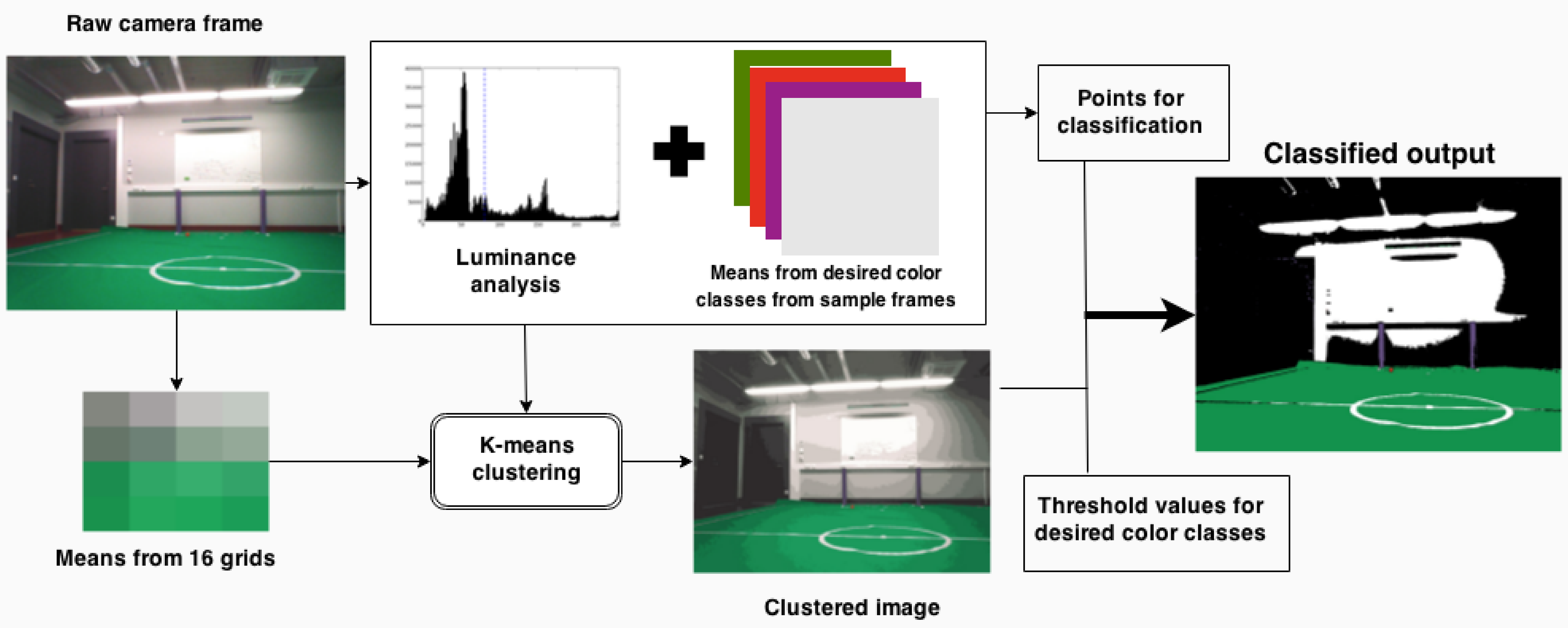
The developed robust and accurate YUV-color-space-based automatic color calibration technique does not involve any conversion between color spaces, **all computational steps are performed in default NAO robot camera format - YUV**.

First, the specific set of frames from the NAO camera have been analyzed in order to define **average values for desired color classes**.

Then those average values are corrected by a **luminance analysis** of a new frame and passed to the **K-means clustering** algorithm as a set of initial means. The frame currently being processed is divided into a 4 by 4 grid, and the **average value from every segment** will also serve as an initial mean for K-means clustering. After the clustering is applied to the frame, so that colors of a similar type are combined into clusters.

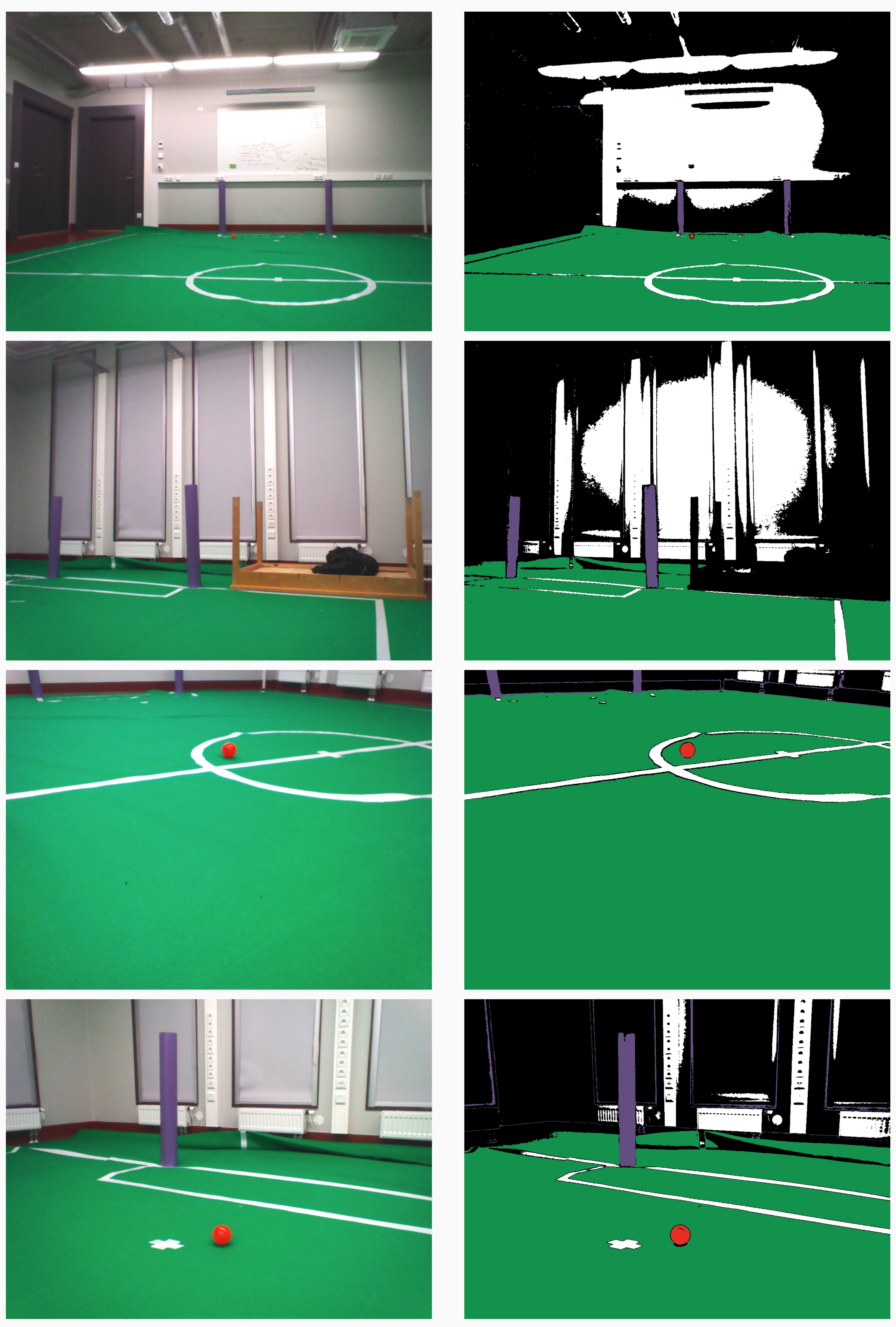
The final step is the **cluster classification**, which is performed by measuring the distance from the cluster centroids to the previously calculated average values of the desired color classes corrected by luminance analysis.

Automatic Color Calibration Algorithm Scheme



Results of Automatic Color Calibration

Examples of **input raw images (left)** and corresponding **classified output frames (right)** after the automatic color calibration algorithm has been applied.



White Goal Detection

Problem One of the RoboCup 2015 challenges is the detection of white goals. In the previous years the color of the goals used in RoboCup competition was yellow, which is easier to distinguish from white field lines. Because of new challenge current goal detection module needed to be updated before it can correspond to the new RoboCup requirements.

Solution Apart from sanity checks that are already present in the goal detection system, the new system implements check whether the top horizontal bound of bounding box containing a possible goal candidate region is above the estimated field edge or not. In case of the field lines, which represent the main noise factor in this particular object detection algorithm, top horizontal bound should always be below the field edge value.
Another additional sanity check controls whether the shape of the bounding box is of a right shape by calculating the length to width ratio and comparing it with the threshold values.

Results The proposed algorithm has proven to provide excellent robustness against the noise caused by the white field lines as well as sufficient robustness against other possible sources of noise.

Localization System Enhancement

Introduction The localization module uses the probabilistic Kalman Filter approach for denoising the information about the observations obtained via processing the sensor data, and models the belief of robot's position on the field with the Gaussian distribution. The uncertainty of position estimation is also calculated by the Kalman Filter and it varies depending on reliability of the current observations.

The aim is to trigger the moment when the uncertainty of position estimation is too big, and change robot's behaviour during the game accordingly, intending to improve the accuracy of position estimation.

Implementation The covariance matrix for Gaussian distributions of the X and Y coordinates is calculated. The Eigen decomposition is performed on the covariance matrix in order to obtain the eigenvectors, which indicate the directions of the variance, and the eigenvalues indicate the variance magnitude. With all that information, the error area of the position estimation can be projected on the 2D surface, and its size can be analysed. The moment when the size of the error area exceeds a threshold value is triggered, and this information is passed to the high-level behaviour module in order to activate the localization scan, when the robot stops actively playing and scans the area around it in order to detect more observations, which decreases the uncertainty of position estimation.

Info

More information at **http://icv.ims.ut.ee/nana** UT RoboCup Team Philosopher: **http://icv.ims.ut.ee/philosopher/** Contact: **bolotnikova.anastasia@gmail.com**