Various Calibration Functions for Webcams and AIBO under Linux

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Abstract: If captured images are processed to acquire some information of the world (e.g. shapes, objects), then it is very important to normalize them. There are many attributes, which should be corrected: the optical distortions of the camera lenses, the pixel error of the CCD chip, wrong brightness etc. Normal webcams and the camera of the AIBO mobile robot have different architectures and they need alternative solutions to capture the images and to normalize them. The myLibrary library developed by the author of this paper integrates various sources under Linux to solve these problems. The goal of this study is to summarize the achieved results and to discuss the ways of the further work.

Keywords: camera calibration, myLibrary

1 Introduction

Linux is an alternative platform against a familiar one it provides an efficient chance to develop scientific applications. However, the support of this operating system is behind others and many times it is difficult to use various hardware sources because of the lack of the device drivers. Another aspect is that a lot of higher-level libraries are well-developed under Unix-like systems and the open-source projects give a chance to add new features to them for everybody.

AIBO is a robot dog as a commercial product was made by the Sony. It opened the door to write robotic applications to reach some goals, which could be worked out only with big efforts without the dog. This robot offers a plaatform that manages the actuators and the sensors and the researcher can concentrate to implement new features and solutions. Unfortunately, the company brake off the AIBO project in spring of 2006 and it gives support the service only for the sold robots yet. Nevertheless, a focus of this study is to use this dog as a capture device to provide calibrated images of the world from AIBO's point of view.

A webcam represents another way to achieve photos from the outside. Images can be captured with drivers of the Linux whose standard API was the v4l and v4l2 [8] in the recent kernel versions. There are small differences of the various drivers and handle of the devices is not the easiest. The capture interface of the Intel's OpenCV library [9] is understandable as a middle-ware between the webcams and the user, as well as it can remove these working anomalies.

myLibrary written by the author is a core library to develop multifunctional applications with a simple interface. It combines more other libraries to reach the most efficient result with the simplest implementation [5].

The next sections contain the expositions of the capture interface, some calibration routines, which are used, then the description of a demo application (CamView) [10] and the summary follows these parts at the end of the document.

2 Capture Interface

The OpenCV functionalities and AIBO were used by the author to acquire images from webcams and the robot dog. The OpenCV has an interface to v4l as well as v4l2 devices [8] and it hides the differences between these two specifications to connect the devices. It is possibly to get/set properties of the capture process and to snap images from the compatible cameras.

AIBO equipped with R-CODE software has wireless connection to communicate with external instances. It can be also used to receive frames of the camera in the head of the robot and a computer can control the robot with telnet-like commands through the network that it can be a feedback for some actions.

The myLibrary [10] integrates these two sources and only the main capture properties must be defined to get frames from the desired device. After the capturing, it can take place the low-level normalization of the pictures what describes the following sections.

3 Optical and Black Calibration

The projection of the outside is conveyed by the camera lens system, which have optical distortions. The different sort of the cameras has sometimes more, sometimes less distortions, but these must be removed from the image stream in the most of the time to have an acceptable form for further work.

The optical calibration serves this aim and the algorithm integrated in myLibrary is the pinhole camera model of the OpenCV [6], that forms a scene view into the image plane by projecting 3D points and perspective transformation [7]. It generates some parameters (intrinsic parameters, radial and tangential distortion coefficients), which were acquired from a series of reference pictures portrayed a calibration chessboard from different views. These once calculated parameters can be stored and can be used by myLibrary every times later if the camera is employed as a capture device again.

The CCD chips have a pixel error in normal conditions: if no light touches the CCD, then not only static zero values are captured because of its technology. There is an easy way to eliminate this pixel error that so-called black calibration. Simply, the door of the objective must be obstructed and save a captured image from this phase. After that, this stored image must be loaded and subtracted from each captured frame, the pixel error will be removed.

4 Auto-Gain

More Automatic Gain Control (AGC) [1] and Auto-Exposure methods [2] are used by digital cameras, video recorders in the normal life. It is important to set the capture image properties (brightness, contrast, gain) to an acceptable value of the shutter speed in the beginning of the capture process.

Here, the used algorithm captures seven images with resolution 176x144 (minimal resolution supported by most of the webcams). The differences between them are the image properties balanced with equal interval on the range of the gain/brightness. Histograms are created from the pictures and two features are calculated:

1. The range of the histogram is 0-255 (0: black; 255: white). This feature is the distance of the centroid point of the histogram from the point 192 (3/4 of the full range). The zero distance is the best.
2. Length of the power interval: Minimum and maximum of the range is where the histogram reaches 10% of the maximum power. The wider range is the better.

Two rankings are made by these features above whose main criteria are nearness of the mentioned distance and the length of the power interval. Each picture gets a score by the given rankings. (A centroid nearer to 3/4 of the histogram and a wider power interval is scored better than a worser result.) The capture image properties of the highest scored image will be applied.

5 Histrogram Streching

The histogram streching is the one of the well-known and the mostly used histogram algorithms to improve a picture. The myLibrary includes a modificated, enhanced version of the original one. This method selects and streches the main power interval of the histogram. The calculation of the power interval is selected by a minimal and a maximal point. These points are determinated by a threshold value what is any percent of the maximum power value of the histogram. The threshold can be 20, 10, 5, 2, 1 in order. The main power range will be selected if the range length is at least 52 units long with a threshold value, otherwise the used threshold value is 1. After that, the main power range is streched to the full range (0-255).

6 Sample Application

The demo application of the myLibrary is the CamView developed in GTK [5, 10]. The current version 0.4 handles the v4l/v4l2 devices and AIBO as a capture device.

If the device was initialized and the auto-gain executed, then the application does the following actions after the capture:

1 Capture a frame (Figure 1).

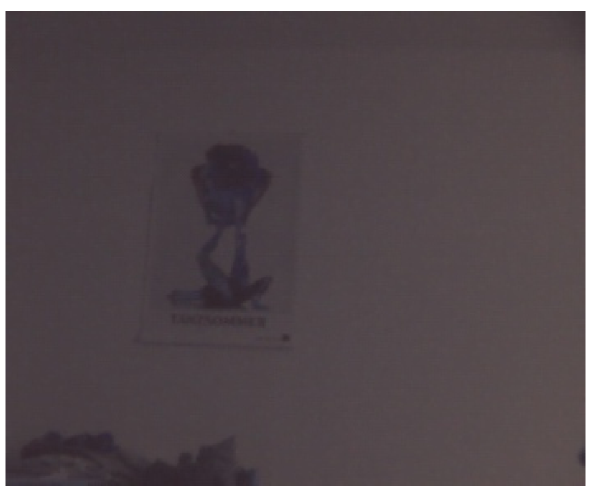

Figure 1
A captured image

2 Mirror the image horizontally. (The camera stands to the operator opposite many times.) (Figure 2)

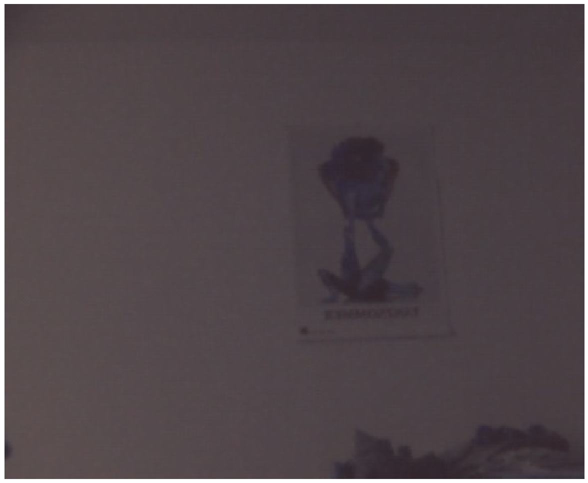

Figure 2
Mirrored image

3 Convert from BGR colorspace to RGB. (Many drivers of the webcams under Linux gives the captured image in BGR format back.) (Figure 3)

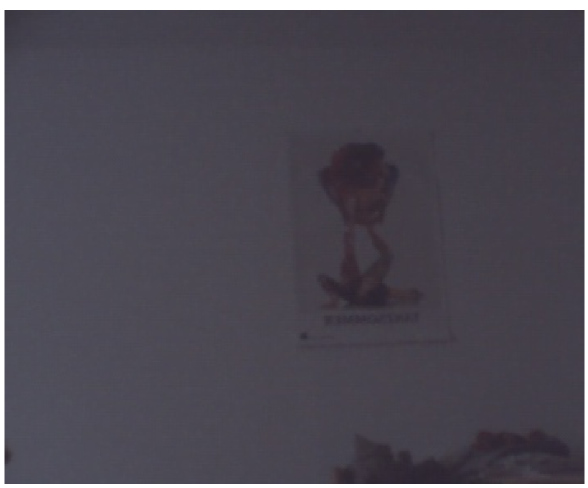

Figure 3
Color space conversion

4 Strech the image histogram. (Figure 4)

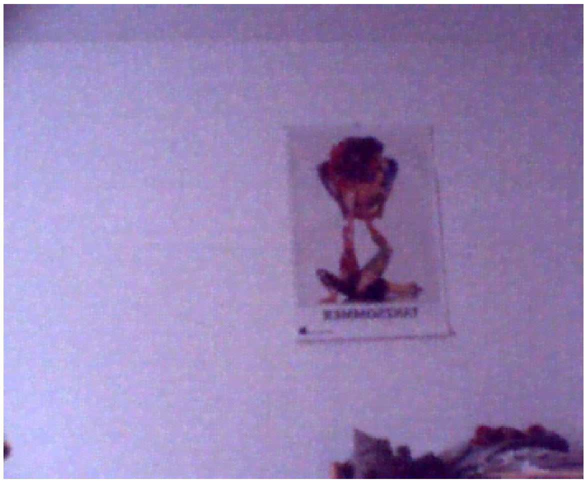

Figure 4
Histogram strtching

5 Remove the distortions with optical calibration. (Figure 5)

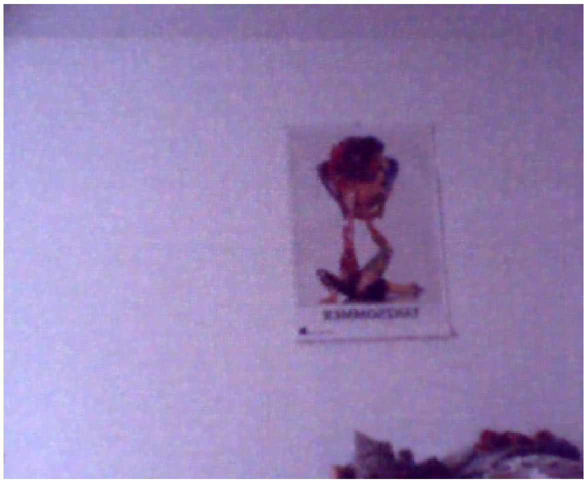

Figure 5
Result after distortion removal

6 Search and show the calibration chessboard on the image if this option is selected.

7 If the capture parameters were re-configured, then apply them and make an auto-gain method.

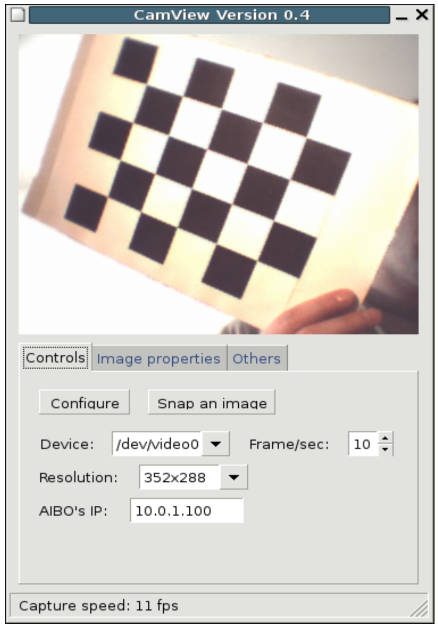

Figure 6
The GUI of CamView

The calibration is integrated in CamView [10] in three ways. Firstly, the program can detect a calibration chessboard with determinated dimensions on the captured image sequence by subpixel accuracy. In the second place, calibration parameters included in the package of this application are available for three camera devices (AIBO about 32 pictures, Trust SpaceCam 120 about 29 pictures and Genius VideoCam NB about 41 pictures). The files with the stored parameters must be copied to the application, run the program and they can be used immediately. Otherwise, the black calibration images place beside the CamView also.

Summary and Future Work

The core library myLibrary and the presented application CamView are an efficient solution to use the various calibration technics and to adjust the appropriate property values of the capture process to acquire the more precise representation of the outside from point of the view of the camera. The detection of the calibration chessboard in CamView is helpful to grab these images to generate the calibration parameters. Nevertheless, worthy of note is that the accuracy of the calibration data was not measured mathematically, because the goal was not an optical calibration in the near of the potential reachable, just the elimination of the most part of the visible deformations was enough.

A further task is to use the implemented calibrations in a recognition problem and to see that these methods are quite robust with other cameras and in additional external conditions. Open question is to do some actions if the illumination strength or the lamp changes fast, after all the aim of the calibration is to provide the recognition algorithms with images with good quality on the next process level and to remove the noise and other aberrations from the image sequence.

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