Explore the possibilities for objective assessment of some beer quality indicators

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Abstract. The aim of this research is to develop an appropriate experimental setting and to explore the possibilities for objective automatic and express assessment of some appearance indicators of beer quality using computer vision techniques. The goal of the research will be achieved by developing a computer vision system, including a hardware module for obtaining primary information and a software module for processing primary information and extracting the desired characteristics through algorithms based on adapted image processing methods.

1. Introduction

One of the oldest and the most widely-consumed low alcoholic drink after water and tea is beer. Beer production is an important branch of food industry worldwide. In 2018, the world beer production amounted to about 1.94 billion hectoliters, compared to 1.3 billion hectoliters in 1998. Leading countries in beer production are China, the United States and Brazil. [1, 2]. The largest producer of beer in Europe is Germany (over 8,295,009,300 liters) followed by Great Britain (4,513,705,000 liters), Poland (4,029,906,900 liters), and Bulgaria ranks 15th (497,602,951 liters). There are two main types of beer - industrial commercial beers and craft beer which has gained great popularity among consumers worldwide. Today, in addition to industrial commercial beers, craft beer is gaining popularity among consumers, especially in the United States. Craft beer is produced by a small independent brewery that uses traditional brewing methods and focuses on the production of beer with a unique taste and quality, rather than on mass production [3, 4]. Beers are differentiated mainly according to the fermentation process and the visual characteristics color and turbidity. Depending on the fermentation technology, beer is categorized into three main categories: with upper fermentation - ale, with lower fermentation - lager and naturally fermented beer - lambic. Another classification of beer can be made in terms of color, which is determined by the color of the malt - distinguish shades of yellow, red, brown and black and are classified as dark, light, red and white beer. The most common color is pale amber, produced from pale malts.

The main ingredients in beer production are: water; malt barley, but wheat, rye, corn, rice, oats, sorghum, einkorn can also be used; brewer's yeast required for fermentation; hops, which flavor, impart bitterness and act as a natural preservative. Some species use additional ingredients, such as herbs and fruits, to add other flavors and tastes [5].

The success of a beer company is based on its ability to consistently produce and deliver a product with qualities that satisfy consumers, which are becoming increasingly demanding. The quality of the beer drink is determined by the quality of the raw materials used and by the technological process of
preparation. In order to ensure certain quality indicators in the long run, disturbing impacts in the course of production must be eliminated, which requires continuous monitoring and management of production regimes. This in turn leads to the need for accurate, objective and reproducible instrumental methods to eliminate the subjective human factor and provide rapid feedback.

The quality of beer is assessed by a complex set of sensory characteristics that include appearance, aroma, taste and texture. These beer quality indicators build a sensory profile specific to each brand and type of beer, and are what consumers expect every time they consume a particular product. Appearance is the first characteristic that the beer consumer evaluates, as the main indicators are related to the color, clarity and foam of the product. Foam is formed by the appearance, rise and release of gas bubbles and is assessed by its height, stability and structure (size and distribution of bubbles). The stability of the foam is an important quality indicator of the beer, as the foam is an effective surface for gas exchange and directs the aromas to the olfactory sensors of the drinkers [6].

The aim of this paper is to explore the possibilities for obtaining primary information for objective automatic and express assessment of some indicators of appearance as a characteristic of the quality of the widely used beer drink. The goal will be achieved by developing a computer vision system, including a hardware module (experimental setting) for obtaining primary information and a software module for image processing and extracting the desired characteristics through algorithms based on adapted image processing methods. The proposed experimental setting has a universal application and can be used to conduct researches on the quality evaluation by objective assessment of some visual quality indicators of a variety of food products - bread, solid and semi-solid dairy products such as different types of cheese and others [7, 8].

The experimental setting described in this report gives the ability for simultaneous assessment of three indicators of beer quality (foam, bubbles and bubble haze) using special developed appropriate experimental setting and analyzing the influence of light during the process of obtaining primary images of beer samples. One common visual indicator of beer quality is the beer foam. Several parameters that directly affect the quality of the foam have been chosen to be analyzed simultaneously. First one, is the stability of beer foam which can be considered as a function of changes in height of the foam in time. The stability of the foam is considered one of the most attractive qualities of the beer. The second and the third parameters are related to the liquid phase of the beer and more precisely the size and distribution of the bubbles moving upwards when beer is pouring into a glass. During dispensing beer into a glass a group of microbubbles arises in the liquid creating an illusion of haze. For the food industry it is essential to measure beer bubble haze size and distribution. Moreover, it is very important to measure and control the bubble size in haze because their size directly affects the spread of taste and flavor of beer.

2. Materials and methods

Each computer vision system is based on the analysis of video or images to obtain characteristics of certain products. Its main components are: a computer, a digital camera and lighting. When the experimental setting is developed, a several factors that will influence the results are considered. The main problems in developing a computer vision system for beer quality evaluation can be seen in two directions. The first is related to the development of an appropriate experimental setting for obtaining the primary information, as it is necessary to eliminate various essentially disturbing influences, most often from the environment, in order to obtain an image that correctly reflects the desired characteristics of the product. The second direction is related to the development of algorithms for processing the obtained images, which allow to extract accurate information about the required quality characteristics. This paper aims to describe the process of development of an appropriate experimental setting for obtaining the primary information and elimination various external disturbing influences.

The main problem that is considered is related with the methods for illumination of the beer samples. Several properties of illumination - angle of incidence of the light, the color of the light source, the light temperature and the technique of direct / diffuse lightening are analyzed.

A special experimental setting is developed. It provides the ability of using different light sources positioned at different angles in order to eliminate some interference such as shadows, reflections and
noise. A project sketch of the experimental setting with lightening sources installed is shown in Figure 1. It is made up by using the following components:

- A digital camera Canon EOS 2000D (1) is used. It is mounted on a tripod (8) for holding the camera in a stable position. The camera is used for obtaining the initial information (images) in raw CR2 format. The characteristics of the camera are: image processor type - DIGIC 4+; 24.1 Mpx resolution; image sensor type - approx. 22.3 mm x 14.9 mm CMOS.

- Four light sources for illuminating the beer samples at different angles and positions (2). It is used four LED UltraLux LGS10342 spotlights with following characteristics: LED type - SMD2835, 3 W energy consumption, 280 lumens, 4200 K Natural light color temperature and the beam angle is 120°. The Color Rendering Index (CRI) is above 80 Ra and warm-up time is less than 0.2 seconds, which characteristics makes the usage of this spot lights suitable for the purpose of this study. The spots are detachable and can be moved from one rail to another which gives more flexibility of the experimental setting.

- Two horizontal rails (3) and two vertical rails (4). They are used for moving the light sources along the X and Y axis and simulate different positions and angles of the lights towards the glass of beer.

- Opaque intermediate plate with a transparent square hole in the center (5). The hole is covered with a glass on which a glass of beer (7) is placed. It is used to raise the beer sample above the bottom light source (6).

- For the bottom light source (6) a LED panel is used. It has 24 W energy consumption, the light emitted is 2400 lumens with color temperature of 4000 K.

- The sides of the experimental setting are covered with black dense opaque material (9). The idea is to eliminate the various external disturbing influences such as day light and artificial lights from the laboratory.

![Figure 1](image)

**Figure 1.** A principal sketch of the experimental setting.

Based on the principal sketch shown on Figure 1 and described above, a real experimental setting is built. It is shown on Figure 2 a), b) and c) where different stages from the experimental process are captured. The experimental setting is built in a scientific computer laboratory from the department of Computer science and technologies in the University of Food Technologies - Plovdiv.
There are different approaches for object illumination under test described in details in [9]. A key moment in a computer vision system for beer quality evaluation is the process for selecting suitable properties of illumination such as light angle of incidence. The main idea in this research is to obtain
high quality raw images in order to extract and evaluate three different important beer quality indicators at the same time – foam structure and stability, presence and size of bubbles and bubble haze. Because of this, the proposed experimental setting is build in such a way that the camera can be placed near to the one of the sides of the experimental setting and points towards the center of the intermediate plate (5) where the glass of beer should be placed. For the purpose of this research two lightening approaches are examined - direct lightening techniques and a backlighting techniques. The proposed experimental setting is build according three direct lighting techniques - angular lighting (45° between light source and the object), lateral angular lighting (90° between light source and the object) and bilateral angular lightining (90° and 60° between light source and the object), shown in Figure 3 a), b) and c) respectively.

Figure 3. Lighting techniques implemented in the proposed experimental setting.

The different lightening techniques are simulated using the horizontal and the vertical rails and the movable spot lights.

3. Experiments
Several different positions and angles of illumination of the beer samples are tested. Two different containers are used to pour the beer - standard cup of glass and a measuring cylinder. Some of the experimental images captured after illumination with a spot lights placed on different position and in a different angles are shown on Table 1.

The results shows that the images with most informative features are obtained using pairs of 2 lights mounted on the horizontal rails and pointed towards the object at 45° angle and also using bilateral angular lightning technique at 90° towards the object.

An additional experiment is made using bilateral angular lightning technique at 60° towards the object. It is used 1 spot light mounted on the upper end of the left vertical rail and 1 spot light on the upper end of the right rail. The lights are mounted in such a way as to illuminate the object at an angle of 60 degrees. The result images show that the important information for foam structure and bubbles of the beer can be extract with further image processing.

For the purpose of this study an open-source software for digital image processing – ImageJ is used. A process of segmentation is performed onto sample images of measuring cylinder and a standard glass for beer. After segmentation a useful information is extracted and a measurements related to the size of beer bubbles are performed.
Table 1. Result images captured after illumination using different lightening techniques.

| №  | Image | Region of Interest | Lights turned ON | Angle towards the object |
|----|-------|--------------------|------------------|--------------------------|
| 1  | ![Image](image1) | 2 spot lights mounted on the left horizontal rail (Direct angular lightening) | 45 degree angle towards the object |
| 2  | ![Image](image2) | 2 spot lights mounted on the left horizontal rail and 2 spot lights mounted on the right horizontal rail (Direct angular lightening) | 45 degree angle towards the object |
| 3  | ![Image](image3) | 1 spot light mounted on the bottom end of the left vertical rail and 1 spot light on the right rail (Direct Bilateral angular lightening) | 90 degree angle towards the object |
1 spot light mounted on the bottom end of the left vertical rail (Direct Literal angular lightening) 90 degree angle towards the object

1 spot light mounted on the bottom end of the left vertical rail (Direct Literal angular lightening) 90 degree angle towards the object

1 spot light mounted on the bottom end of the left vertical rail and 1 spot light on the right rail (Direct Bilateral angular lightening) 90 degree angle towards the object

1 spot light mounted on the upper end of the left vertical rail and 1 spot light on the upper end of the right rail (Direct Angular lightening) 60 degree angle towards the object
Two different glass containers (measuring cylinder and standard glass for beer) for pouring the beer and capturing the images are compared. Several key moments are observed. After pouring the liquid, the standard beer glass does not allow bubbles to remain on the inner wall of the glass, unlike the measuring cylinder where a lot of bubbles are remained on the inner wall and can be further analyzed. For better differentiation between bubbles and the background (the liquid) and and better application of image processing techniques, the measuring cylinder must be clear – without measure markers. The stability and structure of the beer foam is an important indicator of beer quality.

An open-source software for digital image processing - ImageJ is used in order to process the result images and extract useful information related to the beer foam and bubbles. Figure 4 shows the result after processing an image of measuring cylinder and Figure 5 shows the result after processing an image of standard glass of beer. In Figure 4, It is used an image of measuring cylinder with beer poured into it. In this way, the change in the height of the beer foam can be measured. The process of image segmentation consists of several simple steps – cut Region of Interest (ROI) from the original image (1); making the ROI image grayscale (2); adjust brightness and contrast (2.1) – Figure 5; image segmentation using Otsu Threshold and manually adjusting the threshold value (3); applying suitable threshold value for segmentation (4).

![Figure 4.](image1.png)

**Figure 4.** Extracting of information for beer foam with ImageJ and applied image processing techniques. Using image of a measuring cylinder.

![Figure 5.](image2.png)

**Figure 5.** Extracting of information for beer foam with ImageJ and applied image processing techniques. Using image of a standard glass for beer.
For image segmentation of a standard glass for beer an additional processing step (2.1) is required, because of the glares due to the illumination of the glass. In order to analyse stability the beer foam, it is observed that more suitable are images obtained using a measuring cylinder instead of using a standard glass for beer.

Figure 6. Extract information for bubbles – a) ROI from the original image; b) make the image grayscale; c) adjust brightness/contrast of the image; d) apply Otsu threshold; e) image after manual adjusting the threshold; f) apply Dilate function three times; g) image after applying Watershed function; h) counting the bubbles using Analyze Particles function; i) Detect and count the bubbles and summaries information about the area, in pixels, for each detected bubble.
For measuring the exact area of bubbles in square millimeters a calibration process is performed shown on Figure 7. A distance between two measuring markers are manually measured and a special measuring tool in ImageJ is used to determine the exact distance in pixels between the same two markers.

![Figure 7. Performing a calibration process for further measurements.](image)

4. Conclusion
This research explores the possibilities for obtaining primary images and performing an objective assessment of some beer quality indicators. An experimental setting is developed, through which the tested object (beer vessel) is illuminated. The influence of different lighting angles in relation to the test object is studied and appropriate lighting techniques are selected in order to obtain images containing important information about the studied beer quality indicators. A digital camera is used to obtain the primary images. Digital processing of the received images is performed using open source software - ImageJ. The program uses built-in image segmentation functions to extract useful information. Experimental measurements are performed on the size of the bubbles in the liquid phase of the beer. A comparison is made between two different containers for pouring beer - a measuring cylinder and a standard beer glass. Significant differences are observed between the two vessels. It is concluded that it is better to use a measuring cylinder without the presence of measuring markers for performing analysis of the bubbles. Both test vessels can be used to analyze the stability of the beer foam. The developed experimental setting is suitable for lighting objects under a test and obtaining primary information (images), both for testing the quality of beer and for other food products.

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