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Respiratory Mask Selection and Leakage Detection System Based on Canny Edge Detection Operator

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Abstract

Respiratory mask is an essential equipment for workers in industry, chemical research centers where many harmful gases or particles are present. This mask is needed for the security purpose to avoid harmful gases while working in industry. This paper gives an overview of the technology used for the fit test of the respiratory mask and leakage detection occurred in the mask which makes human health more secure. This paper also provides suitable technology for such system based on Canny edge detection operator. The advantages are its low cost, better accuracy, easy to implement and provides better security for wearer.

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Keywords: Respiratory mask; Leakage detection; Wearer; Canny Edge Detector;

1. Introduction

In many industries, Respiratory mask is needed as a protective equipment in order to protect from harmful and poisonous gases. Industries such as Oil and gas, Petrochemicals, Power, Mining, Steelmaking, Metals, Fertilizers, Nuclear power plant are continuously producing harmful/poisonous gases and particles. To avoid the inhalation of

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such gases, respiratory mask is needed[3]. These gases are harmful to human while working in any industry or company. Such gases must be avoided in order to avoid hazardous conditions. This precaution can be possible with the help of automatic selection of respiratory mask. But this mask must be fitted well which is done with the help of selection process of multiple sized respiratory masks.

Sometimes, after the completion of selection process, leakage may occur in the mask[2]. Leakage will permit inhalation of toxic or harmful gases. Formation of leakage is very dangerous during work in the industry when such harmful gases or particles occurred. The manufacturing company provides these types of mask based on the regularly observed face shape. But if some changes occur on the face shape of wearer, leakage will generate. Most of the leakage generates around the chin and nose area of the face. This paper firstly presents a review report on the fit testing of the respiratory mask along with detection of leakage inside the mask. This selection and leakage detection process is important for the certification of fit test for the respiratory mask. The Fit test certificate provides the recommended size of mask according to face shape. Different types of mask depending on the structure are shown in figure 1 below.

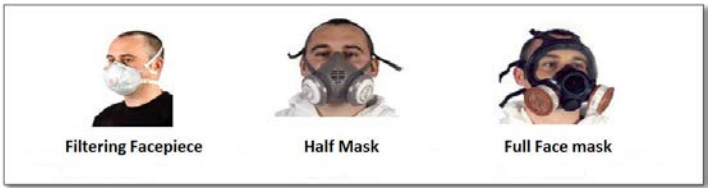

Fig. 1. Types of Mask.

2. Literature Review

An improved mask selection criteria from multi resolution masks for person identification depending on the eye distance captured in the image is proposed[1]. Initially, the system constructed multi-resolution mask cluster pyramid, where the mask size is selected depending on the distance between two eyes, computed from the detected face. System also determines distance between a person and camera based on eye-distance. A person to camera distance is measured with the help of distance between centres of two eyes. A distance measuring system uses the variation in eye distance with the change in distance between camera and person. System provides better results with high precision, recall rates as compared to existing single resolution mask based person identification systems. Result of experiment shows distance measurement system with an average accuracy of 94.11% , precision rate of 88.25% , and recall rate of 80.05%.

The detection of leakage of half-mask and maintenance free respirator equipment is studied theoretically and practically[2]. Also the protection factor and leakage flow has been discussed by using a practical model which uses the equation of particle conservation inside and outside the respirator. For the practical experiment, sodium chloride (NaCl) particles of 10 nm in diameter are conducted. Along with NaCl a condensation nucleus counter is used as particle detector. A respirator is fitted with controlled leak holes of 20-3000 pm in diameter. Protection factor is measured for the high efficiency dust/mist/fume/radioactive nuclide respirator, which is as high as 4.1 X $l0^9$ on the ultrafine aerosol. Experimental results showed that the aerosol penetration into a respirator was strongly affected by the leak hole size, filter efficiency and flow rate through the respirator. Experimental study shows the changes in the protection factor along with the leak hole size and flow rate. Increase in leak hole size resulted into rapid decrease in protection factor and with the decrease in flow rate, protection factor get increased. The conclusion of the study shows that the penetration of particles through the respirator filter can be decreased to a smaller value, and in some cases, negligible value. Thus the characteristics of face seal leakage can be studied with the help of ultrafine aerosols test.

Fit testing of a respirator is needed to ensure that the wearer is fully protected with a proper fit. The purpose of paper[3] is to determine the effect of leakage on the face mask, presence of beard on the face area of the fire fighters and workers in harmful gaseous environments. Basically, paper[3] proposed a detail study on the fire fighters who were works in hazardous condition and always be helpful to others. Total forty volunteer fire fighters from different departments are included in the study. All these fire fighter were analyzed for measurement of leak rate for total five days. Leak rate measurement can be experimented by Control Negative Pressure (CNP) fit tester. After this

measurement, the presence of beard on the face with the respirator leak rates was investigated. The presence of a beard increased the leak rate in spite of the face shape. Result of this study observed the best fitting mask to the respirators as oval shape, then secondly the rounded and finally the rectangular face. Face having beard must be prohibited for experiment, since it can leads to dangerous conditions such as extinguishing fires.

The Respiratory Protective Equipment such as respiratory mask is fit tested with the selection procedure[4]. The selection process is a fit test which is carried out in the laboratory. In laboratory, all the tests including leakage detection is carried out which is very important to avoid hazardous conditions. It produces an accurate results based on the selection of multiple masks. Fit test is carried out with two methods such as Qualitative and Quantitative fit tests which provide the certification of fit test.

2.1. Conclusion Based On Literature Review

Thus existing techniques[3,4] consist of fit test for the selection of mask using fit factor for all the types of masks which is time consuming procedure. Other technique[1] provides image processing based on matching algorithm which determines distance between eyes to select the mask. Basically the fit factor (FF) is a measure of how well a particular mask seals against the wearer's face. To calculate the fit factor for each of the available masks, each mask must go through certain procedure by wearing it by the wearer. Thus mask is selected based on the fit factor records for all the available masks. FF is the ratio of concentration of contaminant outside the mask to concentration of contaminant inside the mask.

$$FF = \frac{\textit{Concentration Outside the mask}}{\textit{Concentration Inside the mask}}$$

A higher fit factor number shows that the mask achieved a good contact between the face seal and the face during test. So for each member of industry, this fit test is done which is more time consuming as compared to system proposed in this paper.

For the leakage detection, existing system uses Qualitative and Quantitative fit test[4].

- Qualitative fit test:- A bitter/ sweet tasting aerosol or odour compounds are passed in the environment for the leak detection which is pass or fail test only.
- Quantitative fit test:- Specialised equipment is required to conduct the measurement by placing the user in an atmosphere containing an easily detectable non-toxic aerosol which is typically performed in a laboratory test chamber.

Both the tests are time consuming, complex and needs special operator to handle such equipment. The system proposed in this paper can detect leaks in the mask with minimum time and no need of separate laboratory test. Thus while working in the industry, wearer get informed automatically if leakage found.

3. Methodology for Mask Selection and Leakage detection

Existing system provides the appropriate face mask on the basis of laboratory test. But this methodology provides suitable methods for mask selection test which uses the image processing technology. The selection system will work as per the flow chart as shown in fig. 3 below. In this fit test process, the face contour will be examined. According to the dimension captured from the face image, best fitted mask will be selected by the software. Edge detection algorithm can be applied to detect edges of the wearer's image. The best selected operator for the edge detection of face image is Canny edge detector which can be used in this system. With the help of evolutionary algorithm and advanced software tools, dimension will be calculated from the captured image. Then this dimension will be compared with the standard dimension of the appropriate mask. Then the best matched dimension will select the mask that will be best fitted to the wearer. Flow chart shows easy operation of system but the difficult part is the image processing which must record accurate reading of face shape. After the selection process, each person can wear mask comfortably without any risk.

Some general shapes of human face are shown below in fig. 2. According to figure, five common types of shape of face are Round, Oval, Long, heart, Square and Diamond. For all types of shape, masks are available but which mask is best fitted to wearer will depend on the selection process. Basically this system works when certain changes occurred on the face area of wearer such as scares, moles around the face mask area, swelling due to any dental work and sometimes wearer loses or gains weight, then the selection test is needed. Sometimes leakage in the mask occurs due to some physical activity while working in the industry. In such condition, indication should be given by this system in order to take safe action.

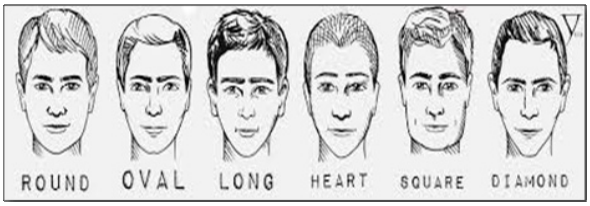

Fig. 2. Common Face Shape.

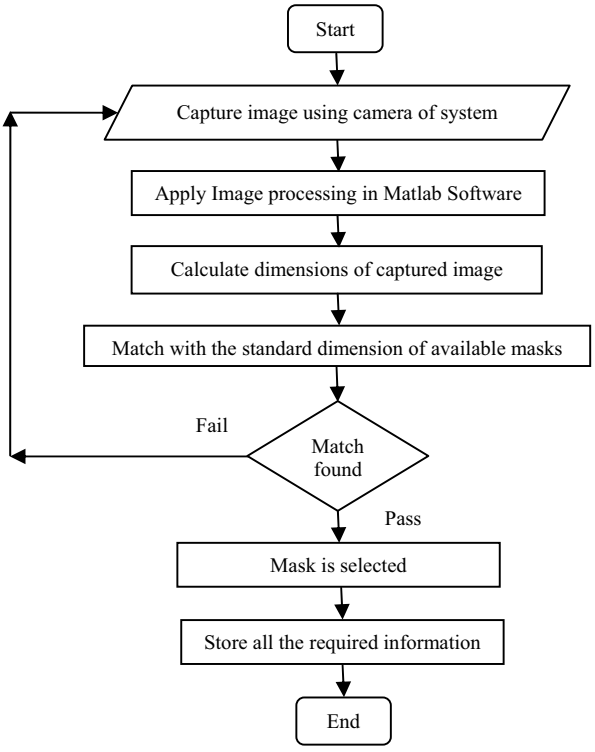

Fig. 3. Working Flow Chart for Mask Selection.

3.1. Canny Edge Detection Operator

Canny edge detection technique is used to detect wide range of edges in the image. It is a best operator used within edge detection algorithm. It was developed by John F. Canny in 1986[12] . Along with canny operator, some

other operators are generally used for edge detection such as Sobel, Deriche, Differential, Prewitt and Roberts cross. Canny edge detector must follow certain operations such as:

- Detection should catch more of the edges shown in the picture with low error rate.
- The edge point detected from operator should accurately localize on the centre of edges.
- Detected edges should be marked only once with low false edges.

In order to follow the above operation, operator must perform some strict methods. Firstly, noise is removed by applying Gaussian filter to the image. Then find the intensity gradients of that smooth image. After applying gradient calculation, edges obtained from such gradient method are still quite blurred. To remove this, non-maximum suppression technique is applied to that image. Thus, it suppresses all the gradient value to 0 except local maximal. There may be some edges which will be caused by the noise and some color variation. To clarify the different types of edge pixel, double threshold method is applied to filter out edge pixel with weak gradient value and preserves edges with high gradient value. Final method is tracking the edges by hysteresis which removes all other edges that are weak and not connected to strong edges. Thus by using all the above methods, Canny operator provides good and reliable detection of edges in the image. Instead of Canny we can use Sobel operator but due to some advantages of canny over Sobel operator as shown in table 1.1 , Canny is better to use to detect edges in the image[13].

Table 1. Comparison between Canny and Sobel operator.

Edge Detection Operator	Strength	Weakness
Canny	Smoothing effect to remove noise	Complex computation
	Better detection specially in noise condition	Time consuming
	Improves Signal to Noise ratio	
	Localization and Response	
Sobel	Simple	Sensitivity to nose
	Detection of edges and their orientation	Inaccurate

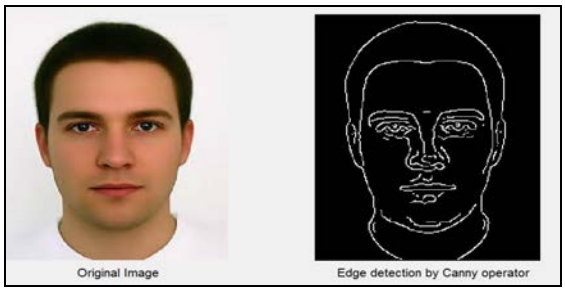

Fig. 4. Example of Canny operator.

3.2. Leakage Detection

Leakage may occur in the respiratory mask due to any physical changes or activity. Inhalation of poisonous gases through the leakage may produce hazardous condition. Hence, finding out leakages within a minimum amount of time is very essential for security purpose. Existing technology proposed an equipment which uses either ultrafine aerosol or odour compounds for testing purpose. Such equipment is costly and requires more time to test. If leakage

occurs in the mask, immediately pressure inside a mask changes. For the detection of leakage, pressure sensor can be used to determine the changes in the pressure inside the mask. Such variations will be observed and proper controlling action will be taken by the controller. Such controller must be best for controlling the inputs and should be of low cost. Such system can be made smaller in size so that it can be easily mounted inside a mask. Methods should follow steps of flow chart shown in fig. 5.

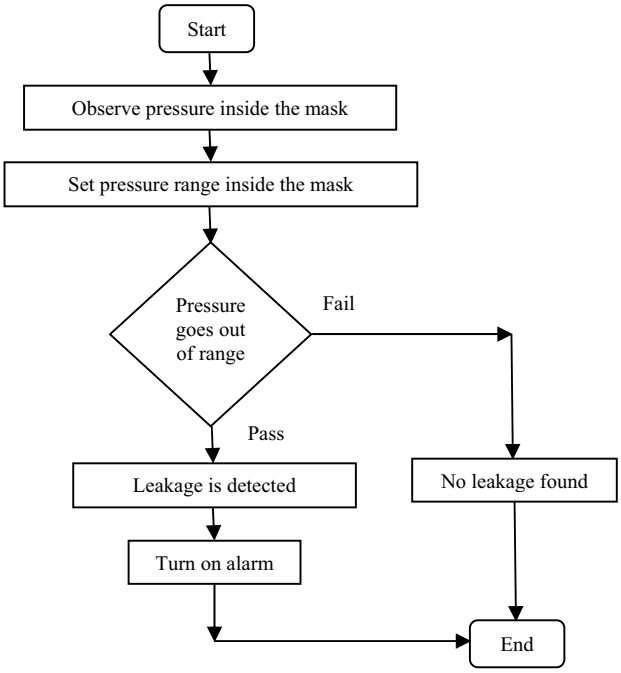

Fig. 5. Working Flow Chart for Leakage detection.

There are some advantages of pressure sensor based leakage detection system over existing system which uses certain test based on non-toxic arousal or compounds. As shown in table 2, detection of leakage will be more effective by using such advance technology.

Table 2. Comparitive analysis for leakage detection.

Parameter	Proposed System	Existing System
Cost	Low	High
Time to process	Less	More
Operation	Easy	Complex
Processing	Continue (while working)	Whenever needed
Accuracy	Good	Good
Operator	Not needed	Needed
Size	Small	Large

4. Conclusion and Future Scope

In this paper, an overview of mask selection and leakage detection system is discussed with the help of certain existing technology. This paper also reviewed existing methods and provides some conclusion based on it. By overcoming the time consumption and complex operations in the existing technology, methods proposed in this paper provides appropriate selection of mask during the changes on face shape area. System will also detect leakage automatically before any hazardous condition may occur. Small industries can use this system for the security purpose. Report in this paper discussed different face shapes which commonly exist. By using advanced technology of edge detection, matching method and leakage detection, this system will provide better accurate result and early indication. Thus system will be used for the security of human health. System will have advantage that there is no need to go for laboratory test every time for mask selection. Also this paper shows that Canny is better operator to detect edges in the image than Sobel operator by comparing certain strength and weakness of both the operator.

Technology has been rapidly changing to fulfil today's worlds increasing demands. In future, detection of leakage with exact location will be possible with the help of light rays moving along a boundary of mask. Such system will be complex but it would detect leakage accurately along with the exact position.

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