VIDEO QUALITY ENHANCEMENT USING INTERACTIVE GENETIC ALGORITHM

Ms. Seena Teresa George, Ms. Jissy Liz Jose

Abstract— Even when so many video processing techniques and tools are available, video quality enhancement is a cumbersome task for a layman. This is mainly because of two reasons, the existing techniques may not prove good to be used as a standalone system that could work efficiently under any circumstances and the user should have some basic knowledge about how to use the system and what changes it makes on the video. Video Quality Enhancement using Interactive Genetic Algorithm, aims at designing and developing a system that could work as efficient as the existing systems and overcome their shortcomings. The system uses a combination filter to enhance the video and genetic algorithm is used to tune the input parameters of the combination filter. Interactive genetic algorithm is used so that the user can control the evolution process, by choosing best videos, after each iteration of the genetic algorithm, and get an enhanced video according to his emotions and intuitions. The system was tested using System Usability Test (SUS) and was found to be effective, efficient and satisfactory in performance, while enhancing videos with very average visual quality.

Index Terms— Video quality enhancement, Interactive genetic algorithm, Image filters, image processing, evolutionary algorithms, Combination filter, Graphical User Interface

————————————— ◆ —————————————

1 INTRODUCTION

AN image is an important medium to store, record and share data. Developing good quality images is a very essential requirement. The techniques that produce better images, so that their visual quality is improved are collectively known as image enhancement techniques. A video is a collection of images (frames) and hence can be mentioned as a motion picture. The methods that are used to improve the quality of a video are called video quality enhancement techniques. There are several enhancement techniques available for improving the video quality including histogram equalization, contrast enhancement, smoothing/sharpening filters, blur removal etc. But all these methods, suitable for one condition or application may not be suitable for the other.

There are several existing methods to enhance the quality of a video which uses different image processing techniques. But to use of these techniques one should be an expert in image processing, because one should know, what is the effect of each of these techniques on the video. Another problem is that, these image processing techniques, suitable for one application may not be suitable for another operation. Hence it cannot be used for general purpose operations.

A second option is to use video enhancement tools available in the market. To do so, one should have the software exclusively installed on their systems and should have a basic knowledge about working of the system. Both of the above mentioned disadvantages, of the existing systems, can be overcome by the proposed method.

The proposed system combines four different image enhancement filters, which is then applied on the video, to get it enhanced. Hence the system can be used for videos captured in different conditions and for videos used for different applications. Another advantage is that, in the proposed approach the user needs to have little knowledge about basics of the image enhancement techniques used to enhance the video. Hence it makes it easier for a layman to work with the system.

A third challenge is that, a video that appeared enhanced for one user may not appear the same to another user. This problem do not come to play in our system because, the system uses human interaction for deciding the fitness value of each chromosome. So the user can optimize the solution according to his idea of an enhanced video.

The rest of the work is organized into four sections. Section II includes literature survey. Section III presents the proposed work. Section IV shows the experimental results and section V deals with the conclusion.

2 RELATED WORKS

The proposed work emphasis on enhancing the quality of a video using interactive genetic algorithm. The system mainly consists of two modules – a combination filter and application of interactive genetic algorithm to it. There are several image processing techniques available for enhancing the quality of a video. Literature survey includes study on the different techniques for image processing and has used a better method combining different filters, which includes all the advantages of existing systems and adds to it. Similarly, for a layman, the knowledge of basics of image processing is very essential for working with any tools. The proposed work develops a system that uses genetic algorithm to tune the parameters of the combination filter, so that system itself produces different variations of the video which is to be enhanced. The user just needs to select the video which he thinks, is the best or is close to settings of an enhanced video. The literature survey also includes basic concepts of genetic algorithm and various image processing techniques that have already been done using genetic algorithm principles.

Literature survey is structured into three sections. The first section includes use of filters in image enhancement. The

second section deals with survey on concepts of genetic algorithm. And the third section is a survey on various works done in image processing area using genetic algorithms.

2.1 Use of filters in image enhancement

Digital image enhancement refers to development of a processed image that is suitable for various applications. Image enhancement algorithms can be classified based on two properties - An image enhancement algorithm utilizes either point or spatial processing, and whether it incorporates linear or nonlinear operations. Point-processing algorithms work on each pixel separately. Use of filters for image enhancement comes under point processing. Image enhancement filters enhance the quality by applying a mathematical equation on an image. There are basically three types of image enhancement filters:

    a.   Algebraic filters: Uses a mathematical equation to generate an output pixel by applying the equation on input pixel.
    b.   Parametric filters: Uses a parametric function
    c.   Structured filters: Uses a combination of both algebraic and parametric filters.[1]

2.2 Genetic Algorithm

"Computer programs that "evolve" in ways that resemble natural selection can solve complex problems even their creators do not fully understand"
-John Holland [4]

Inspired from the process of natural evolution, genetic algorithm is type of computational model that encode any problem's potential solution in the form of a chromosome. This solution is then evolved when subjected to selection and recombination. Thus the potential solution can be fine tuned into an optimal solution. Genetic algorithm encompasses two important components – problem encoding and evaluation of fitness function.[5] The problem has to be encoded in the form of a chromosome of suitable structure. A chromosome can be encoded as a binary string consisting of 1's and 0's.

This chromosome is used to generate various population of which the selection operator chooses the best offsprings against the less fitter ones. The choromosomes may also be subjected to cross over and mutation. Cross over referes to exchange of subparts of two choromosomes , which corresponds to the recombination of two single chromosome organisms in the biological world. Mutation applies random changes in bits at various positions of the chromosomes. [6] Inversion may also be applied in which includes reversing the order of a set of contiguous bit positions of a chromosome.
Hence generally the working of a genetic algorithm can be summarized into the following steps:

1.   Randomly generate an initial population of chromosomes
2.   Evaluate the fitness function value of each of the chromosomes.
3.   Repeat the following steps until N number of off springs are generated:
    a.   Pair of chromosomes is selected to act as par-

ents to generate offspring in the next iteration. They may be chromosomes producing high values for fitness functions.
    b.   Applying a certain crossover probability the chromosomes are subjected to cross over at a certain point.
    c.   With a specific mutation probability mutates the off spring and the resulting off springs are produced in the next population.
4.   Use the newly generated population as current population
5.   Repeat step 2 [5]

2.3 Image enhancement using genetic algorithms

An automatic image enhancement technique was done based on real-coded Genetic Algorithms. In the paper, genetic algorithm is used for contrast enhancement [13]. Another work used Evolutionary Computation for colour image enhancement for images taken with various illuminates and automate it[14]. Interactive evolutionary computation was also used for designing and optimizing image enhancement filters with fewer parameters than normal filter model. Here optimisation speed was increased by combining interactive and non interactive evolution [15].Differential evolution was applied in image contrast to get an adaptive contrast enhanced image[16].Genetic algorithm was also used for morphological image enhancement [17]. Work was done to enhance the colored images using the enhancement developed steady state genetic algorithm, SSGA, with modified fitness function to get more accurate result and less noise [18. Genetic algorithm was used for contrast enhancement in medical images using morphological filter [19].   Genetic algorithm was also used to enhance palm print and preserve information by optimizing the value of entropy based beta and gamma [20].   Contrast enhancement was tried using GA [21].

3 PROPOSED METHOD

Video Quality Enhancement using Interactive Genetic Algorithm aims at improving the quality of a video by combining various image enhancement techniques with IGA which uses human emotions and priorities to find an optimized solution. Combination of various image enhancement techniques makes the system suitable for various applications. The use of genetic algorithm makes it easier for layman users to get their video's quality enhanced without having a deeper knowledge of the technology behind it. We are using an Interactive GA, so that the user can evaluate and control the solutions given by the system according to his intuitions.
The working of the system can be briefed as follows. The VQE system using IGA captures input video. The system applies random values to the parameters of the combination filter to generate an initial random population. The user selects one solution, which he thinks, has enhanced his video, or is closer to his concept of an enhanced video. If the user is satisfied with the solution, the settings of that particular solution is applied to the video, otherwise the selected solution is used to

generate the next population by applying genetic algorithm. The above process is repeated till the user finally gets his video enhanced or a specified number of iterations is reached.

The proposed system consists of three modules namely combination filter generation, application of IGA and design of interactive GUI. The first module-combination filter generation further comprises of generation of four filters namely brightness filter, contrast filter, gamma curve filter and color value filter. The second module includes the following sub-modules-generation of random initial population, selection, crossover, mutation and termination condition. Finally third module deals with design and working of an interactive GUI to facilitate the system.

3.1 Combination filter

Several image processing techniques are available for enhancing the quality of a video. Applying filters is one of the methods that are suitable for all types of videos. Here we have designed a combined filter which includes all the advantages of individual filters and adds to it. A combined filter includes four different filters. A brightness filter improves the lighting condition in a video. The contrast filter helps to emphasis on a person or any specific object in the video. The gamma curve filter improves the quality of video irrespective of the medium of display and finally the color value filter helps to maintain the color balance of the vide. The color tone of a video may sometimes define its emotions. Hence the color value filter may also be used to add an effect to the video. The value of input parameter may differ according to the nature of the filter. Range of these filters may be mapped to a value between 0 and 255, because we are using an 8 bit value to give input to these filters. This will be explained in details in the following sections.

Brightness filter

The brightness filter increases or decreases the intensity of light in an image. The brightness filter can be applied to all three channels-Red, Green and Blue separately. The following equation is used for improving the brightness of video.

$$C\_Red_{new} = C\_Red_{old} + B_v \qquad (1)$$
$$C\_Green_{new} = C\_Green_{old} + B_v \qquad (2)$$
$$C\_Blue_{new} = C\_Blue_{old} + B_v \qquad (3)$$

Here C_Red indicates the red channel. B_v The brightness value can take a range from -128 to +127. If the brightness value is in the negative range the image becomes darker and if it is in the positive range the image becomes lighter. C_Red_{new} indicates new value of red channel which must be mapped to a range between 0 to 255. Similar changes can be applied to green and blue channels also.

Contrast filter

Specific objects or people in the video can be en-

hanced by contrast enhancement. Contrast enhancement filter works by enhancing the variation between a set of pixel and its neighbors. The following equation shows how the contrast filter works.

$$c\_Rate = [259 (c\_Level+255)]/ [255(259-c\_Level)] \qquad (4)$$

$$C\_Red_{new}=c\_Rate(R_{old}-128)+128 \qquad (5)$$

Here c_Rate indicates the rate of contrast. C_Level is the level of contrast. It can take values from -128 to +127. . C_Red_{new} indicates new value of red channel which must be mapped to a range between 0 to 255. Similar changes can be applied to green and blue channels also.

Gamma Correction filter

Gamma correction is a non linear operation used to change the luminance value of an image . This is very suitable for video enhancement because human presumes luminance or colour in a non linear manner. The gamma curve changes each color value as human sees. Gamma correction filter can be applied to each of the three channels in the image. It can control the overall brightness of the image and the ratio of red, green and blue colors in the image. Gamma correction filter can be designed as follows:

$$gamma\_Correction = 1/ \gamma_{red} \qquad (6)$$
$$Red_{new}=255*(Red_{old}/255)^{gamma\_Correction} \qquad (7)$$

In the above equation γ indicates the slope of the gamma curve and hence can take values between 0.2 to 5.0 .Since this input has to be maintained as a binary value, the following equation can be used to estimate the value of γ_{red}

$$(8)$$

$$y=\begin{cases} \frac{x}{128} + 0.2 & x < 128 \\ \frac{x-128}{128} * 4 + 1 & x \ge 128 \end{cases}$$

Here x is the old colour value and y gives the value of γ_{red} which ranges from 0 to 255. Similar correction can be applied to all three channels of the image

Color Value filter

The color value can enhance or remove a specific color by shifting the color histogram. Color value filters are band pass filters generally. The working of color filter can be explained as follows:

$$C\_Red_{new}=C\_Red_{old}+ cv\_Red \qquad (9)$$

cv_Red can take values from -128 to +127. This must be mapped to a range 0-255 and can be applied to green and blue channels also.

3.2 Interactive Genetic Algorithm

Next phase of the proposed system is application of Interactive Genetic Algorithm to tune the input parameters to the

combined filter. All these input parameters are mapped to the range 0-255 and are converted to 8-bit binary format. These parameters form a chromosome structure and are fed to the GA. The working of IGA is explained in details in the following sections.

Structure of chromosome

A genetic algorithm transforms its potential solution to a specific problem, in the form of a chromosome. We have all together 8 input parameters. Each of these parameters is mapped to the range 0-255(2^8). All these parameters can be represented as 8 bit binary numbers. Hence we have a 64 bit chromosome.

Brightness (8 Bits)	Contrast (8 Bits)	γ_{red} (8 Bits)	γ_{green} (8 Bits)	γ_{blue} (8 its)	cv_red (8 Bits)	cv_green (8 Bits)	cv_blue (8 Bits)

Fig 1 : Structure of chromosome

The structure of the chromosome is as shown in Fig 1. First, we match parameters in a chromosome to predefined filters. And an initial filter is combined with the predefined filters such as brightness, contrast, gamma curve, and color operation. If a combined image filter is made, it can refine images faster than four separate image filters because of only one time retouching by LUP (Look-up-table). A method to generate image filter using a chromosome is shown below.

Generation of Initial Population

The initial population of a genetic algorithm is generated randomly. The 8 input parameters can take values from 0 to 255. To generate the initial population a pseudo random number generator is used to generate inputs to the filters. If the values are generated randomly between 0 and 255 the desired output may not be obtained. Hence we identified a suitable range for each of the parameters and pseudo random generator is made to generate numbers in this range. These values are applied to the filters to generate 8 variations of the input video randomly.

Selection and Fitness Evaluation

As already mentioned, an image that looked enhanced for one user may not appear the same to other. Hence we have developed our system using an interactive GA so that the user can evaluate the results of iterations and control the direction of optimization of solutions. Selection of best candidate is done interactively by the user. After every iteration, 8 variations of the input video are produced. From those user selects the one which he thinks is the best. If the user is satisfied with selected candidate image, the chromosome values of that particular solution are applied to the entire video.

If the user is not satisfied with the solutions of current iteration, he selects a solution that is closest to what he thinks, is an enhanced video. This video is considered as the first parent. Now a fitness evaluation function is used to calculate the

Euclidean distance of all the other solutions from the selected candidate solution is found using the following Equation

$$\text{Fit}_i = \sum_{i=1}^{n} \sqrt{(Gi,j - Gbest,j)^2} \qquad (10)$$

In the above equation, Fit$_i$ presents ith fitness value of ith individual. In Gi,j, Gi is ith individual j is jth parameter of Gi. The distance between genes, give their relative fitness value. Based on that, the one with minimum distance is given highest rank and similarly for all genes. The gene with highest ranking is taken as second parent. This way the user only have to select one option at each stage, but filters similar to the best gene will survive in the evolution process.

The selected parent genes are subjected to cross over and mutation, which will be explained in the following sections.

Crossover

Crossover is a genetic operator that combines two chromosomes to produce a new chromosome. The idea behind crossover is that the new chromosome may be better than both of the parents if it takes the best characteristics from each of the parents. Crossover occurs during evolution according to a user-definable crossover probability. After selection process, we have two parent genes – one selected interactively by the user and second, the gene with highest ranking in fitness evaluation process. These two parents are subjected to one-point cross over. Each of the chromosomes is of 64 bit length. 4 random positions are selected on the 64 bit chromosome, and at each of these positions the parent genes are subjected to cross over. That is, all bits of the chromosome, to the right of the selected position will be swapped. Thus we get 8 new chromosomes which will eventually form next generation.

Mutation

Mutation is a genetic operator that alters one or more gene values in a chromosome from its initial state. This can result in entirely new gene values being added to the gene pool. With these new gene values, the genetic algorithm may be able to arrive at better solution than was previously possible. Mutation is an important part of the genetic search as help helps to prevent the population from stagnating at any local optima. Mutation occurs during evolution according to a user-definable mutation probability. This probability should usually be set fairly low. If new generations are produced only by applying cross over, after a few iterations, the solutions will converge. This will prevent the user from getting many variations. The choice of solutions available to the user will be limited. To avoid that the system have implemented mutation. According to a pre specified mutation rate, the bits in the resultant chromosomes will be flipped. Hence the solutions will not converge in a few iterations.

Termination

The execution of the system terminates in any of the following two conditions, i.e. either the user gets his video enhanced or a predefined number of iterations are completed. The proposed system does not take too much iteration to reach
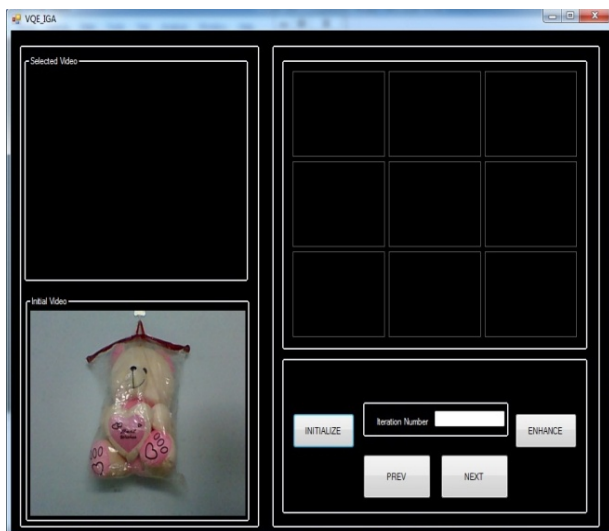
the solution. Hence the predefined number of iterations will be small. The number of iterations required for termination can be varied by the user according to his choice.

3.3 Interactive GUI

An interactive GUI was developed for facilitating the users or making the system user friendly. One section of the GUI shows the initial input video. Another section has an "Initialize" button to generate the initial random population, "Next" button to apply GA and generate next generation, a "Previous" button to move to the previous iteration and a field displaying the current iteration number. A third section displays the 8 variations of the input video from each iteration. Finally the settings of the selected candidate image is applied to the video and shown in one section of the GUI. An "Apply" button, applies the final changes to the video to get it enhanced.

4   EXPERIMENTAL RESULTS

Video Quality Enhancement was done for webcam captured videos. The system was tested by 10 different users, who did not have any expertise in any image processing techniques for video enhancement. The users worked with the system in two different conditions, one with very poor lighting conditions and video quality and other with an average lighting and video quality.
The Fig 2 shows working of the system using an interactive GUI. The working of the system in the first three iterations is shown below
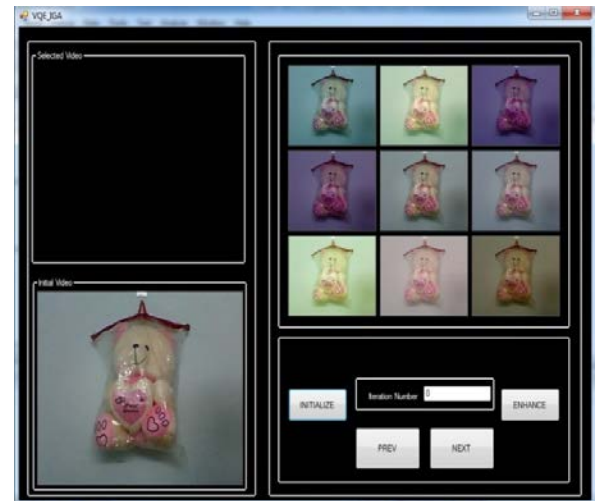
Fig 3 : Random Initial Population

Fig 4 : One candidate selected from initial population
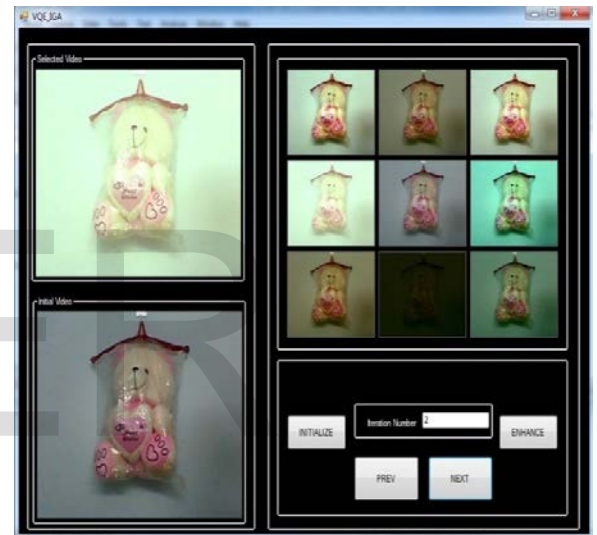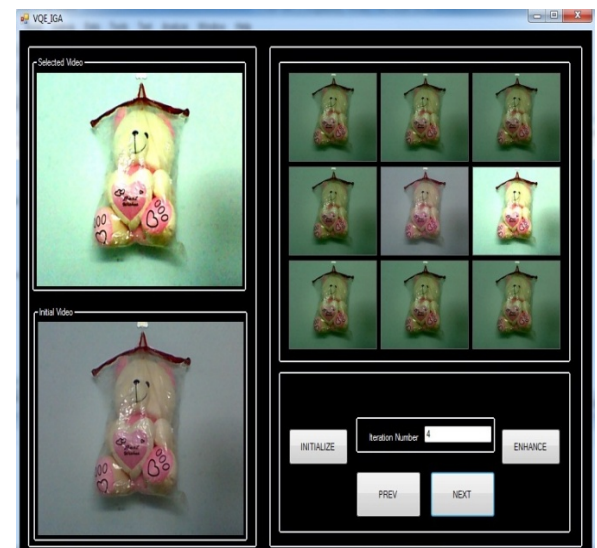
Input Video

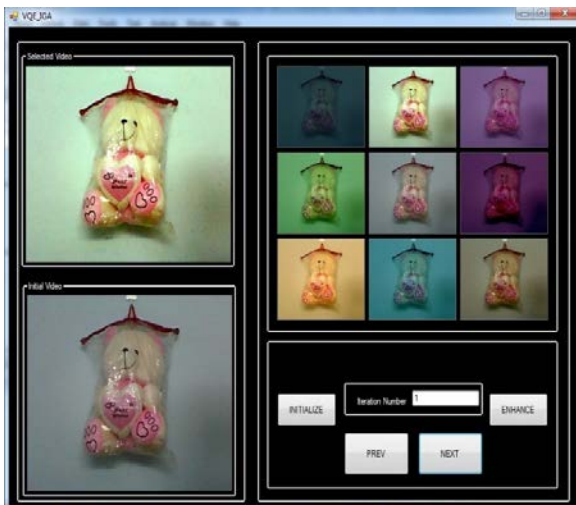Fig 2: GUI Design and

Fig 5 : 1st Iteration of IGA
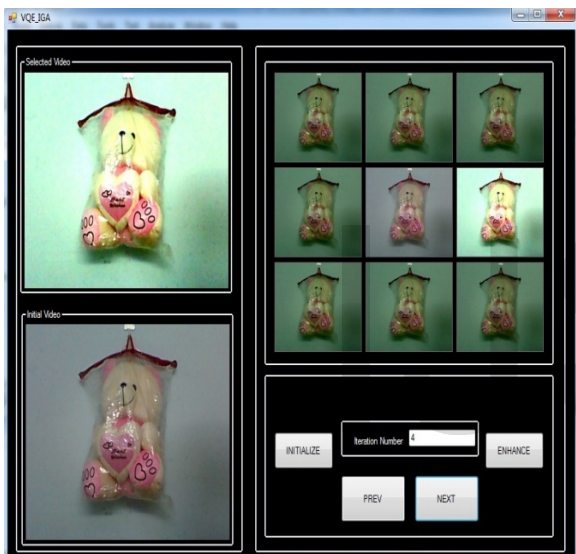
Fig 6: 2nd Iteration of IGA

Fig 7: 3rd Iteration of IGA

Result analysis:

System Usability Scale (SUS) test was conducted to prove the effectiveness of the system. SUS test inspects three characteristics of a system:

1. Effectiveness (How successfully the user can achieve their objective)
2. Efficiency (How much effort and resources is expended on achieving those objectives)
3. Satisfaction (Was the experience with system satisfactory)

The SUS system consists of 10 item questionnaire with 5 response options. The questions can be rated on a 5 point scale ranging from strongly disagree (1) to strongly disagree (5).The higher score of answer in odd numbered questions, the better the system is. On the while, even numbered questions are vice versa[22].The Questionnaire has the following questions as shown in Table I

Table I : Questionnaire for SUS Test

Qn No	Question	1	2	3	4	5
1	I think that I would like to use this system frequently.					
2	I found the system unnecessarily complex.					
3	I thought the system was easy to use.					
4	I think that I would need the support of a technical person to be able to use this system.					
5	I found the various functions in this system were well integrated.					
6	I thought there was too much in consistency in this system.					
7	I would imagine that most people would learn to use this system very quickly.					
8	I found the system very cumbersome to use.					
9	I felt very confident using the system.					
10	I needed to learn a lot of things before I could get going with this system.					

Scoring SUS :

- For odd items: subtract one from the user response.
- For even-numbered items: subtract the user responses from 5
- This scales all values from 0 to 4 (with four being the most positive response).
- Add up the converted responses for each user and multiply that total by 2.5. This converts the range of possible values from 0 to 100 instead of from 0 to 40.

Good SUS score:

Studies show that, the average SUS score is 68. Any score above 68 is above average and anything below 68 is below average.

The test was conducted with 10 users. The users were requested to complete the questionnaire based on their experience with the system under two different conditions- very poor quality video and average quality video. The result of the test is tabulated in the following Table II

Table II: Tabulated Results of SUS Test

User	Score after SUS Test	
	Average conditions	Very poor conditions
User 1	70	62
User 2	74	68
User 3	69	60
User 4	71	63
User 5	75	69
User 6	73	67
User 7	69	61
User 8	72	65
User 9	75	70
User 10	74	69

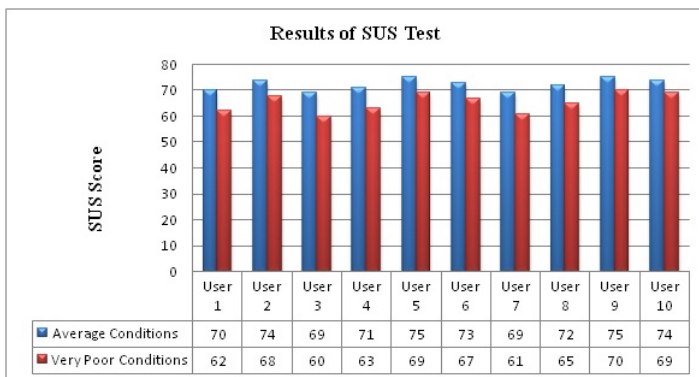The results of SUS test is shown in the form of a bar graph in Fig 8.

Fig 8: Result of SUS Test

Results shows that the average SUS score of the system under average conditions is 72.2. This may be interpreted as; the system's working condition is above average under average conditions. But the average SUS score of the system under very poor conditions is 65.4, which means the performance of the system under poor conditions need improvement.

5 CONCLUSION

The work aimed at developing a Video Quality Enhancement System using Interactive Genetic Algorithm. The system was designed to implement two shortcomings of the existing VQE methods. The existing systems failed to work as a standa-lone technique, under different conditions of input video. This disadvantage was overcome in the proposed system, as our VQE system combines four different video quality enhancement filters, which not only makes it as good as the existing approaches, but also adds to the functionalities. Another problem faced by the existing tools was that, laymen were forced to learn some basics of image processing in order to use the tool. This problem was also overcome in our system by the use of IGA. Using IGA, the system by itself generates outputs by tuning the parameters of GA and the user just have to select one image at everyiteration.VQE according to user's priorities was also satisfied in our system. The system was tested using SUS, and proved to be above average for average quality of videos. The project may be extended by adding more filters to the combined filter, so that the result is improved for very poor quality videos. Also it may be extended to develop applications like video enhancement tool for online video chatting, or adding effects to videos etc.

REFERENCES

[1] M. Rudolf Jaksa, Hideyuki Takagi, "Tuning of Image Parameters by Interactive Evolutionary Computation", *IEEE* 2003.

[2] Nikolas P. Galatsanos, C. Andrew Segall, Aggelos K. Katsaggelos," Digital Image Enhancement", *Encyclopedia of Optical Engineering*, DOI: 10.1081/E-EOE 120009510.

[3] Raman Maini and HimanshuAggarwal, "A Comprehensive Review of Image Enhancement Techniques", *Journal of computing*, Volume 2, Issue 3, March 2010, ISSN 2151-9617.

[4] John H. Holland, "Genetic Algorithms", *Scientific American*, July 1992.

[5] Darrell Whitley, "A Genetic Algorithm Tutorial", *Statistics and Computing*, June 1994, Volume 4, Issue 2, pages 65-85

[6] Melanie Mitchell, "Genetic Algorithms: An Overview"

[7] HeikkiMaaranen, KaisaMiettinen, AnttiPenttinen, "On initial populations of a genetic algorithm or continuous optimization problems", *Springer Science Business Media*, 20 July , 2006

[8] Tobias Blickle, Lothar Thiele, "A Comparison of Selection Schemes used inGenetic Algorithms", Tech Report, Computer Engineering and Communication Networks Lab (TIK),Swiss Federal Institute of Technology (ETH) Zurich, 1995.

[9] Rakesh Kumar, Jyotishree, "Blending Roulette Wheel Selection & Rank Selection inGenetic Algorithms", *International Journal of Machine Learning and Computing*, Volume 2, Number 4, August 2012Tomasz DominikGwiazda, "Genetic Algorithms Reference"

[10] Wen-Yang Lin, Wen-Yung lee ,Tzung-Pei Hong, "Adapting Crossover and Mutation Ratesin Genetic Algorithms", *Journal of Information Science and Engineering*, 2003

[11] Mike Sewell, JagathSamarabandu, Ranga Rodrigo, and Kenneth McIsaac, "The Rank-scaled Mutation Rate for Genetic Algorithms", *International Journal of Information and Communication Engineering* 3:5 2007

[12] C. Munteanu, A. Rosa, "Towards Automatic Image Enhancement Using Genetic Algorithms", Proceedings of the 2000 *Congress on*

Evolutionary Computation,La Jolla, CA, Pages 1535 – 1542,volume 2, July 2000

[13] CristianMunteanu,Agostinho Rosa, "Color image enhancement using Evolutionary principles and the Retinex theory of color constancy", Proceedings of the *IEEE Signal Processing Society* Workshop , North Falmouth, MA, Pages 393 - 402 ,September 2011

[14] Rudolf Jaksa, Hideyuki Takagi, "Tuning of Image Parameters by Interactive Evolutionary Computation", *IEEE* 2003.

[15] Qingyun Yang, "An Adaptive Image Contrast Enhancement based onDifferential Evolution", Proceedings of 3rd International Congress on Image and Signal Processing (*CISP2010*), 2010

[16] Jun Wang and Ying Tan, "Morphological Image Enhancement Procedure Design By Using Genetic Programming", Proceedings of the 13th annual conference on Genetic and evolutionary computation, New York, USA Pages 1435-1442 ,2011

[17] Prof. ReyadhNaoum, Ala'a Al-Sabbah, " Color Image Enhancement Using Steady State Genetic Algorithm", World of Computer Science and Information Technology Journal (WCSIT), Issue : 2221-0741 Volume 2, Number 6, 184-192, 2012

[18] B.Lakshmi, G.Lingaiah, S.S.Madhavi, "An Enhanced Approach for Medical EDGE Image Enhancement using Genetic Algorithm", *International Journal of Computer Science and Technology* ,Volume 3, Issue 1, January - March 2012

[19] S. Palanikumar1, M. Sasikumar, J. Rajeesh, " Entropy Optimized Palmprint Enhancement Using Genetic Algorithm and Histogram Equalization",International Journal of Genetic Engineering, 2012

[20] AkhileshVerma, Archana, "A Survey on Image Contrast Enhancement Using Genetic Algorithm",*International Journal of Scientific and Research Publications*, Volume 2, Issue 7, July 2012

[21] T.M. Jung, Y .S . Lee, S .B.Cho, "Mobile Interface for Adaptive Image Refinement using Interactive Evolutionary Computing", IEEE 2010.

[22] J. Brooke. "SUS: a quick and dirty usability scale," *Usability Evaluationin Industry*, pages 189-194, 1996.