User Generated Sketch Input for Graphical Database Searching and Other Applications

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Abstract: - It is of interest to investigate alternatives to the keyboard and mouse as methods of creating input for use by computer systems. Voice recognition systems are developing into useful tools which avoid the need for the user to interface with the computer by the process of typing or mouse actions. The work reported in this paper is a preliminary investigation of a novel approach to user input by means of the creation of user generated sketches. Two examples of applications which utilise the new method have been investigated.

A user who is interested in performing a search of a graphical database may not be able to easily describe in words the object(s) of their search. This may be the case for young users or users with limited vocabulary skills. If such users are able to create simple sketches, with the assistance of computer drawing peripherals, then the classification parameters of the sketched objects may be compared to the equivalent parameters of an image database content. In this way matches between the sketch and the available images can be generated.

The ability of users to create accurate sketches of objects may be assessed and reported upon in order to provide an intelligent training system which helps the user to improve her/his skills. The user can select an image to be sketched from an available image database and is then required to draw a sketch of the object(s). The user-generated sketch is compared, in terms of the classification parameters, to the original image, which acts as the reference. A score is computed depending on the match found and suggestions made to the user about how to improve the match. The user can then create a revised sketch using the suggestions and continue until an improved score is attained.

Both example applications require that original graphical images be processed to the point where the object of interest has been reduced to a form which is similar to that which may be expected in a human generated sketch of the object. This image processing task is identical in both cases so a generic processing algorithm sequence has been created for this task. The comparison of the user-generated ‘drawn sketch’ and the computer generated ‘machine sketch' is also a generic function required in both applications. It is only in the use made of the results of the matching process that the two applications differ. The paper describes the image processing, the matching operations and the methods adopted to utilise the results of matching for both applications.

Key-Words: - Graphical user interface, graphical database search, sketch recognition. *CSCC'99* Proc.pp..6361-6366

1 Introduction

In the modern age we take for granted the fact that computers have a major rôle to play in many forms of communication. It has now become recognised that the methods utilised for human-computer interfacing should not be restricted to those which the *computer* finds easy to deal with, but instead should be of a type which the *human* finds easy to deal with. This approach has produced some innovative alternatives to text-based input devices (keyboards) for computer systems. Well-known examples of such developments are the introduction of the mouse and speech recognition techniques. Since prehistoric times, one of the most important methods of communication used by human beings has been the drawing and understanding of sketches produced by hand. Although it is now commonplace to create and handle highly complex images in computer-based systems, little work has been done to allow users to easily create, and then use, hand drawn sketches in computer applications. The creation of sketch input for computers is possible with currently available peripherals, but there is normally very little done with this input other than to retain it in its original form. There are advanced methods available from the field of virtual reality [1] which permit users to input 2D and 3D sketches to computer based systems. Engineering designers have contributed to the difficult problem of using sketch input for computer systems [2,3,4,5,6,7,8,9,10,11]. This work has clearly identified some of the problem areas associated with the use of hand-drawn sketches, as far as computer systems are concerned. Firstly, sketches will provide only 'vague' information rather than 'precise' information. Secondly, even when two humans are sketching the same object, they will often produce quite different results. Thirdly, the way in which humans interpret sketches varies with experience, background, etc. Some attempts have been made to produce quantified comparative data with the aim of highlighting the differences between sketched objects using techniques such as 'juxtaposition diagrams' [12]. There has also been work done on the creation of human sketch-like output from computer applications which attempt to re-create the appearance of a hand-drawn sketch. Some of the characteristics of hand-sketching which are emulated include line endpoints overshooting at intersections, non-straight lines and varying line thickness. Random and fractal methods have been used for this purpose, including 'random midpoint displacement'.

The work reported in this paper investigates the possibility of allowing a computer user to create sketches of objects and then to *use* the sketches for various purposes. The research is required as part of a European Commission collaborative research project (MODULATES) which encourages young children in schools to make language independent searches of graphical databases whilst learning about technology topics. The experiments concentrate on the *use* of the sketched input rather than its creation. The basis of the investigation is that it is possible to apply image-processing algorithms to images of interest and thereby extract a sketch-like version of the original image. This 'machine sketch' can then be compared to a user generated 'drawn sketch' using numerical methods. Thus, it is possible to quantify the relationship between the original image and a hand drawn sketch of it. Similarities and differences can then be used for matching purposes. This technique was investigated initially as a means of permitting users to draw a sketch of an object and then to perform a search of a graphical database for images similar to the sketch. In this case, the original database images require to be processed into machine sketches to allow comparisons to be made with the hand drawn sketches. In the case of the investigation being conducted, the main objective is to allow users with limited vocabulary (especially *technical* vocabulary and jargon) and/or keyboard skills to perform searches of graphical databases.

During the investigation, it became clear that the method could also be used as a didactical sketching ability monitor and training tool. Using the same image processing techniques, and the same numerical comparison methods as for the first application, a 'score' can be evaluated to indicate how good the match is between the hand drawn sketch and the machine sketch. Feedback of the score to the user allows improvements to be made to the sketch and the score re-evaluated.

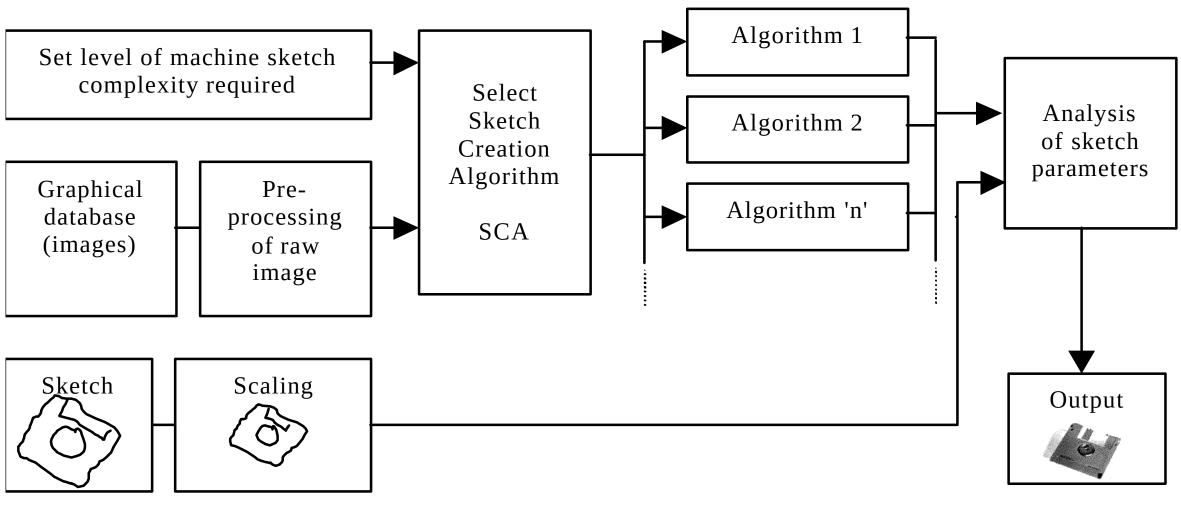


Figure 1 - Sketch Input for graphical database Searching system (SIS)

2 Sketch Input for graphical database Searching (SIS)

The need to investigate and develop new methods for the interrogation of graphical content databases is ever more urgent as the growth of such databases is increasing dramatically. There are tools available such as QBIC and Virage which perform image database search and retrieval operations. The purpose of the present work is to investigate a method which allows users to draw a simple sketch of an object which needs to be searched for, and then to use this sketch as the basis for interrogating a graphical database. The outline of the SIS system created to achieve this is shown in Figure 1.

3 Sketch Accuracy Monitor (SAM)

Because of the power of sketching as a communication medium, it is of great value to assist people to become proficient in both the creation and the interpretation of sketches. Drawing and sketching has always formed a part of early learning. Children are encouraged to experiment with their graphical skills from a very early age. Later in life it can become important to be able to draw accurate sketches which are easy for others to interpret and understand. A computer-assisted hand drawn sketch scoring system has been devised using the techniques discussed previously. The user is asked to carefully study the image which has to be sketched. The user then draws a sketch of the image. The SAM system processes the original image to create a machine sketch. It then performs the matching operations and arrives at a score for the accuracy of the sketch. For the preliminary experiments, a score of 0 to 5 has been used with higher scores representing more accurate sketches. The user can continue the cycle of sketching and scoring until high scores are obtained consistently. No attempts have been made to refine the technique with respect to the user interface at this stage. Included in the potential features of the SAM system are assessments of the following abilities:

- sketching skill
- power of concentration
- power of detailed analysis
- complex information synthesis
- symmetry recognition
- handwriting

Figure 2 shows the block diagram of the SAM system designed as a modification of the SIS system.

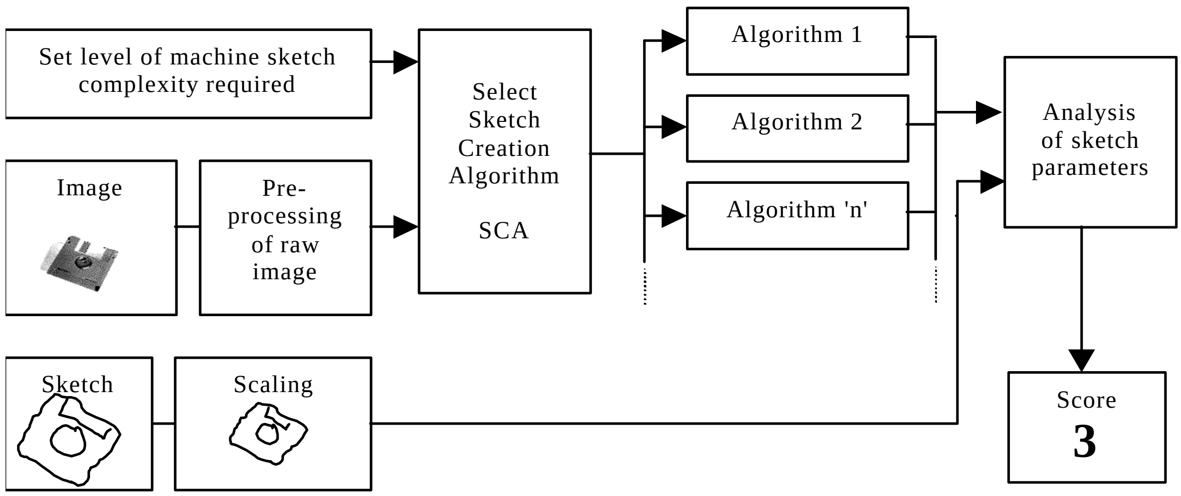
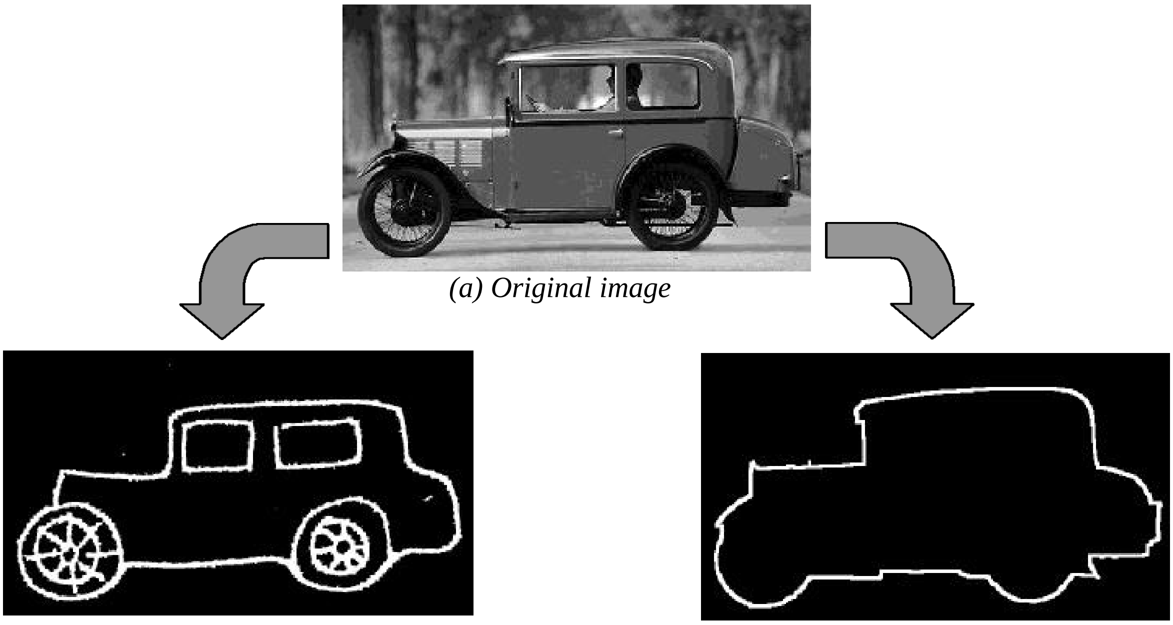


Figure 2 - Sketch Accuracy Monitor system (SAM)

4 Image Processing Operations

Following the image processing operations which were used for the creation of the machine sketches, a range of image parameters were calculated for each of the images being used. These parameters formed the basis of the comparison between the image of interest and that/those being compared to. In the case of the SIS system, the objective was to elucidate from the image parameters which images in the database gave the closest match to the parameters calculated from the drawn sketch. In the case of the SAM system the objective was to assess the extent to which the parameters calculated from the machine sketch differed from those of the drawn sketch. In both cases the processing operations and activities were exactly the same. Only the input conditions and the interpretation of the results were different.

No rigourous attempt has yet been made to assess the relative merits of the various parameters calculated as being more or less suitable to solve the problem being considered. This assessment will form the basis of future work. Figure 3(a) shows an illustrative example of the appearance of one of the original images used in the experiments along with it's associated drawn sketch at (b) and its machine sketch at (c).



(a) Original image

(b) Drawn sketch

(c) Machine sketch

Figure 3 - Example of the Creation of a 'Drawn Sketch' and a 'Machine Sketch'

5 SIS System Results

The investigation of sketch input for graphical database searching was conducted by selecting objects to be searched for. The choice of objects was based on knowledge that images of such objects existed in the database being used. Sketches of the sought objects were drawn and saved as image files (these are the drawn sketches created by the user). By using the sketch creation algorithms (SCA) on the images in the graphical database, a machine sketch of each image was produced. This machine sketch was then compared to the scaled, drawn sketch and comparative parameters produced from the analysis. The results of these analyses allow a 'best match' to be decided, and the image in the database most closely matching the sketch is displayed or identified to the user. Table 1 shows the results obtained from evaluation of parameters on 3 typical examples of images worked on. It should be noted that all images used in the overall study were TIFF images of motor cars, and therefore have much general similarity with each other. The parameters listed are selected from those calculated and are chosen to demonstrate that use of appropriate parameters allows a close match to be made between a drawn sketch and a machine sketch. The accuracy of matching was calculated on the basis of correlation coefficient values for this preliminary study. Good matching is indicated where the correlation coefficient takes a very high value close to unity. It can easily be seen by inspection that good correlation exists between all of the drawn sketch/machine sketch pairs.

6 SAM System Results

The experiments to assess the potential of SAM for learning to improve sketching ability were conducted by asking users to sketch objects which were already available as image files. The sketches were also saved as image files. The original object image was processed by the SCA, and a machine sketch obtained. After scaling, the drawn sketch was applied to the analysis system for parameter comparison to be made with the machine sketch. Table 2 shows some of the parameters calculated which allow clear differentiation between the drawn sketch/machine sketch pairs. In this case it is differences between the parameters for each pair of sketches which matters. The results of the matching comparison were used to compute a normalised score from 0 to 5 which was representative of the general similarity between the sketch and the original object. Higher scores indicate more accuracy of the sketch.

Table 1 - Some image parameters used in the SIS system

	Area Fraction	Centre of Gravity X	Orientation of Inertial Axis	Shape Factor
Image 1 machine sketch	67.9634	255.843	7.59214	1.92502
Image 1 drawn sketch	66.893	263.022	7.8752	1.95487
Image 2 machine sketch	61.1634	256.815	-0.361825	2.72465
Image 2 drawn sketch	60.7925	253.615	-2.31959	1.96966
Image 3 machine sketch	63.1622	269.456	-5.17303	2.03656
Image 3 drawn sketch	65.1894	273.906	-7.19038	1.64543

Table 2 - Some image parameters used in the SAM system

	Perimeter	Centre of Gravity Y	2nd Order Moment	Excentricity
Image 1 machine sketch	1651	127.674	-1674.82	0.152983
Image 1 drawn sketch	1594	116.889	-1897.4	0.183324
Image 2 machine sketch	1551	90.4222	103.907	0.328078
Image 2 drawn sketch	1632	133.609	671.8	0.226772
Image 3 machine sketch	1418	87.738	1362.84	0.259768
Image 3 drawn sketch	1710	133.907	1714.22	0.149649

7 Conclusions

The original problem to be solved was that of developing a system which will allow a user to draw a sketch and then use this sketch as the basis for searching a graphical database. It can be seen from the results presented that the problem can be partially solved with the aid of the SIS system.

It is also clear that the basic functionality of the SIS system can be modified for use in other applications. The SAM system is an example of such a development. It has been shown that the SAM system is capable of quantifying differences between an original image and a user drawn sketch. Evaluation of a score related to the accuracy of the drawn sketch can be performed and reported back to the user.

The methods and techniques described in this paper are intended as the preliminary description of systems and tools which will evolve from the ongoing work. There will be other applications which are also able to use the conceptual approach outlined here.

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