EXPERT SYSTEM FOR INVESTIGATION OF PHOTOGRAPHIC IMAGE QUALITY.

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COMMISSION I.

ABSTRACT:

An expert system was developed under Borland's Turbo Prolog for judging photographic image quality in order to facilitate the ranking of photographs in production. In the first part of the program the knowledge base is collected containing the necessary preliminary sensitometric, meteorological, on-board photographic, control sensitometric, image densitometric and optional MTF data for ranking. In the second part the program investigates the data of the mission troughout a chain of "if then else" relations, following the human expert's thoughts and announces its decision in a Quality Report.

The software written to IBM PCs or Compatibles needs complete and reliable data collection and it partly studies the contradictions between the on board protocol and the physical data as well.

KEY WORDS: Expert System, Image Quality

1. INTRODUCTION AND TASK

The aim of the stand alone Expert Systems (ESs) is to replace the human experts in cases they are not accessible or are expensive and so on. Sometimes the ES Report may facilitate the communication between human experts in the discussing of a special problem, which needs broader agreement. The ES conveys information to the users as well who are not experts at all, but they would like to know the value of their films. Finally it reacts back to the producers as well. The experiences having been collected from the earlier mission may be used in the next one and the Report stimulates the thinking within the complex aerial photographic process.

Not all of human expert activities may be computerized nowadays. Technological processes are more suitable for these purposes than pure intellectual activities. Well defined technological expert areas with 10-100 rules may be optimal for ES applications.

The extension of the fifth generation languagues and the ES Shells are creating an effective environment for programming because these languagues are rather declarative opposed to procedural ones used for other photogrammetric purposes. It means that the human expert may formulate the problem generally in rules which are applied for the special cases of Missions. (Smith, 1988.) Our aim was within this project to write an ES which comprehends the whole air photographic process and follows the way of the film from the test sensitometry of the stored film material troughout the photography and the development till the user in a Report which describes the story and qualification of the film as it is shown in Appendix I.

2. THE ROLE OF THE INFERENCE ENGINE

The developed sofware may be followed on Fig. 1. Let us consider the role of the inference engine on the top of this figure. The software itself consists of series of facts and rules. The inference engine is the internal driving force of the system which has the ability to look trough the knowledge base where the data are collected in form of facts and it applies the rules written in general form for the discrete cases of single films in order to construct the Report about the film requested.

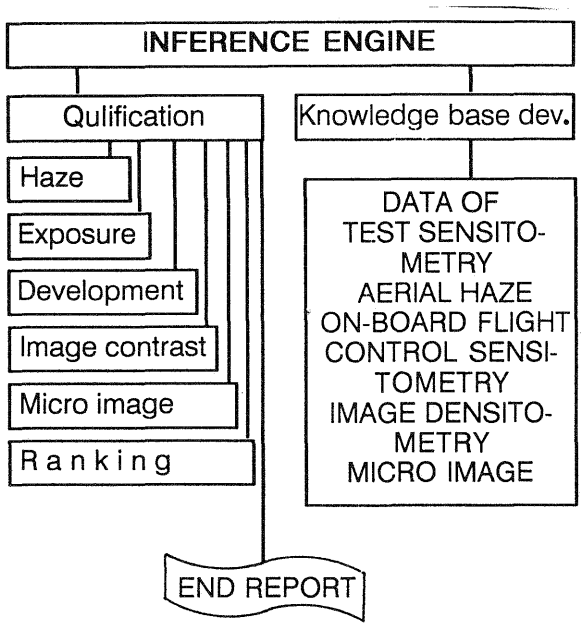

Fig. 1. The block diagram of the AIRPHOT Expert System

Some parts of the inference engine like backtracking are given within the Prolog library while the others are written by the "knowledge engineer" who was identical with the human expert in this project.

We can imagine the work of inference engine as it searches the solution relentnessly from top to the bottom in both sides of Fig.1.

3. THE DEVELOMPMENT OF AIR PHOTOGRAPHIC KNOWLEDGE BASE

The ES written under Borland's Turbo Prolog uses a .DBA file which consists of facts while the rules are imbedded into the AIRPHOT.EXE file. The data used for investigation are collected in an internal knowledge base which is called onto the main program at the start of executing. The internal data base has its own advantages and restrictions. Opposed to external data handling the acces times may be shorter but the main program cannot handle more than one thousand Missions taking into account 640 KB memory.The program sends message about the free memory existing for further data input. The Prolog itself allowes developing external data base as well but it needs longer acces times. The facts are organized into groups containing data of film test sensitometry, description of meteorological situations,on-board data of photography, laboratory data of photographic development,control sensitometry, image densitometry and optional data of micro images.

3.1. Preliminary Test Sensitometry.

When the aerial film material arrives into the stock, the sensitometric data are investigated and compared to the data sent by the film manufacturer.The values stored in facts are:No of emulsion, Type of emulsion,Dfog, Gamma and Speed. The facts may be referred by the
No. of emulsion.

3.2. Description of Meteorological Condition and Visibility.

The photographic staff characterize the haze and smoke conditions in situ which influence the image quality . These are judged value of horizontal sight, the type of clouds and cloud cover if they are present, the verbal description of visibility. Most important is the judgement of horizontal sight, while the other parameters are used in the descriptive part of the report.

3.3. On-board Photographic Data.

The on-board photographic data are collected in separate facts. These consist of the most important photographic data which are used for description of the mission or partly for qualification. The input data are the No. of mission, No.of emulsion, date and time of the mission,type of field, flight height, data of exposure and the names of the flying staff. The data will appear in the descriptive part of the Report, only the flight height related to the horizontal sight will be evaluated. The on-board photographic data may be achieved by the No. of Mission.

3.4. Data of Photographic Development.

The data of photographic developments are stored in development facts. The characteristic data are the No. of Mission, Type of processor, type of developer solution, time and temperature and the name of the responsible laboratory personnel. The data are used in the descriptive part of the Report.

3.5. Data of Control Sensitometry and Image Densitometry

The data of control sensitometry and image densitometry are collected in the after development clauses, whose are identified also with the No. of Mission. These are the control gamma, control speed,Dfog, Dmin, Dmax. These data together with the test sensitometry play an important role in this program so that these data are essential for the evaluation.(Boberg,A.,1988.)

3.6. Data Input from Edge Gradient Analysis.

The ES is prepared to use data optionally collected out of a separate program protocol of EGA on line measuring program developed for aerial photographs before. The parameters are the height/diameter ratio of Line Spread funtion, and the factor of the MTF which is calculated by linear regression, before the MTF is linearized with two fold logaritmisation.

3.7. Some Remarks to the Knowledge Base Development.

The ES deals with the knowledge base development as well. The knowledge base has to content reliable data, otherwise the decisions will fail. The data collection has to accomodate to the on-board protocol usual in different countries and organisations, so that slight modification of the program may be necessary. But the fundamental data of test and control sensitometry and image densitometry may not be absent.
The main program is prepared for correcting and deleting of data in the knowledge base as well.

Now we have already understood that the ES needs some slight modifications before it is transported, because it has no Shell like adaptability.

4. RULES FOR QUALITY EVALUATION

The other part of the System is the collection of the expert rules summarized in the left side of Fig.1. The rules follow the thoughts of a "tame" expert when he studies the on-board and laboratory protocols in order to investigate the film quality and rank it into classes. The computer makes the same: the facts placed in the knowledge base are investigated with the rules built into the main program. Conclusions are drown and appear in the Report.

The expert rules may be divided into two main groups. In the first one the data are interpreted and explained a bit more freely in order to stimulate the personnel for thinking continually in technological processes refining them with "tiny steps".

The second part of rules contains the national regulation for ranking films into one of four quality groups.

4.I Rules for Judging Aerial Haze and Smoke

It is known that aerial haze and smoke showes large variety within the
photographic season and aerial conditions which are highly responsible for degradation of fine details in picture. The flying staff decides in situ whether the atmospheric conditions may be tolerable from the viewpoint of Mission. The program takes into account the quotient of horizontal sight and flight height. The aerial conditions are good if the value of this quotient is higher.

There is another way for judging haze conditions. It is known that the logE range of the film among others depends upon the haze conditions. It was observed that maritime air mass decreases visibility higher than continental ones and it decreases the the logE range of photographs and the contrast of fine details as well. Eight rules deal with the evaluation of haze conditions in this system. The emphasize is made on logE range calculated from the sensitometric and image densitometric data, but the horizontal sight is interpreted too. In this program the logE range > = 1 is accepted as excellent value. In our test group which cosisted of 39 films we have found only one film that reached this logE range.

4.2 Rules for Evaluation of Camera Exposure.

Although cameras with automatic exposure control are generally used today, the evaluation is necessary in order to refine the automation and cooperation between flying and laboratory staff. The exposure is evaluated from the sensitometric and image densitometric data. Using the Dmin value of image density five rules deal with the interpretation of the camera exposure.

4.3. Rules for Evaluation of Image Contrast.

The photographic development is studied with the help of the comparison of test and control sensitometry. Other important factor is the density range of the film which is optimal between 0.9-1.3 D. Further four rules interpret the density range of the photographs.

4.4. Rules for Evaluation of Micro Image.

The ES is prepared for interpretation of Edge Gradient Analysis optionally. It is supposed that EGA was made with the help of a separate measuring program from which the data are introduced into this data base. The system ranks the films from the micro images separately so that the ranking after micro and macro densitometry does not lead necessarily to the same result. The micro contrast and tone reproduction are two different needs as it is documented in APPENDIX II.Eight further rules deal with the interpretationof decutance and Q factor. (Gerencser,M., Winkler,P. 1988.)

4.5 Rules for Ranking into Quality Groups.

The second group of rules ranks the aerial films into one of four quality classes following the ideas of national aerial photographic regulations. The general classification is the last decision of the Report as it is shown in APPENDIX I. If the film got "unsuitable" qualification the decision is reasoned as it is documented in APPENDIX II.

5. EXPERIENCES WITH THE USE OF ES.

The ES runs properly if the knowledge base is filled upompletely with true data. It assumes and needs discipline in data collection. But this requirement is familiar for everybody who deal with data banks and PCs at all. Only the microphotometric data may be omitted. Although the lack of some descriptive data do not hinder the running of the system, the appearance of "No comment" does not increase the value of the Report. It is important that the agreement and cooperation of technical staff give further possibilities for usable description of aerial haze and for further evaluation of it too. In this case only restricted key words would be used.

6. SUMMARY AND CONCLUSIONS.

Aerial Photographic ES has been developed for IBM PC and Compatibles. The system is written under Borland's Turbo Prolog as a stand alone .EXE file which uses a further .DBA knowledge base file as well. The .DBA file is loaded onto the main file and used as internal data base. Taking into account the 640 KB memory of the AT286, not more than a thousands film can be stored at once. The development of external data base is also possible in Turbo Prolog with somewhat longer access times. The system is capable for developing and deleting data base, which always precedes the qualification. The qualification rules and reasonings are built into the software, the ranking follows the national regulations.

The application of ES in production needs the best cooperation with the flying and laboratory staff in order to get reliable data and restricted key word description of the phenomena in order to build them into the system. The freer interpretation of rules in the first part of the Report may stimulate the personnel for thinking in the processes, refining them continually, as the Prolog searches the solution relentness as well.

7. REFERENCES

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APPENDIX I.

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H U N G A R Y
E U R O P E.

AERIAL PHOTOGRAPHIC EXPERT REPORT

by the AIRPHOT Expert System.

I was requested to qualify the No. 9-033 Film.
I can tell you the following:
The Film was made by Mr.Vajner-Bene from not commented area onto b&w Film with Em No. 572-12 at flight height 900 m.
The day and time of the flight is : 89.04.08 ,11.15-11.21.
The YHD-type plane was flown by Mr.Kemény-Halász, and was navigated by Mr.Györgyi.
The Mission was made at 180 km/h flying speed with type 2092 camera and with Uag152 cone.
The 6 km horizontal sight was estimated visually which is -rounded- 7-fold of the flight height.
The verbal description of atmospheric conditions and clouds type was no comment and no comment respectively.
The cloud cover was characterized with the octa number i.e. 0/8.
There was a proposition of the photographers for developing: no comment.
The film was developed by Mr.Mayer on Versamat processor in DK-50 solution at 20 C ,8 Min.
After the developing the density range of the film was measured.
The characteristic values are:
control D0 = 0.21 test D0= 0.1
Dmin= 0.48
Dmax = 1.57
δD = 1.09.
log δE=0.83
The value of control Gamma = 1.32 The value of test Gamma= 1.28.
The 28 Din control Speed and 30 Din preliminary test Speed were compared.
The description of the film acuity is:sharp.
The edge function was not measured.

The evaluation of No. 9-033 Film is :

The No. 9-033 was exposed at 6 km horizontal sight and received no comment description about the atmospheric conditions.
The visual acuity was described with the key word:sharp.
The Film is exposed correctly because the 0.27 value of Dmin is within the optimal 0.2-0.3 D range.
The Film is slightly overdeveloped because the value of control Gamma has increased from 1.28 to 1.32 while the Speed has changed from 30 to 28.
The density range of the Film with its 1.09 δD value falls into the optimal range 0.9-1.3 δD according to the need of analog or digital processing.

GENERAL QUALIFICATION:The Film is Good quality.
Székesfehérvár 4.3.1992.

AIRPHOT Expert System

APPENDIX II.

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AERIAL PHOTOGRAPHIC EXPERT REPORT

by the AIRPHOT Expert System.

I was requested to qualify the No. 90-029 Film.
I can tell you the following:
The Film was made by Mr.Kocsis from mixed agricultural area onto b&w Film with Em No. 33-077 at flight height 2420 m.
The 5 km horizontal sight was estimated visually which is -rounded- 2-fold of the flight height.
The verbal description of atmospheric conditions and clouds type was hazy and cirrostratus respectively.
The cloud cover was characterized with the octa number i.e. 0/8.
There was a proposition of the photographers for developing: no comment.
The film was developed by Mr.Csordas on Versamat processor in DK-50 solution at 24 C ,6 Min.
After the developing the density range of the film was measured.
The characteristic values are:
control D0 = 0.14 test D0= 0.15
Dmin= 0.41
Dmax = 1.02
δD = 0.61.
log δE=0.4
The value of control Gamma = 1.52 The value of test Gamma= 1.48.
The 24 Din control Speed and 26 Din preliminary test Speed were compared.
The description of the film acuity is:sharp.
The edge function was not measured.

The evaluation of No. 90-029 Film is :

The No. 90-029 was exposed at 5 km horizontal sight and received hazy description about the atmospheric conditions.
The visual acuity was described with the key word:sharp.

The Mission No. 90-029 Film is probably very hazy because the atmospheric conditions decreased the LogE range onto 0.4 value.
The Film is exposed correctly because the 0.27 value of Dmin is within the optimal 0.2-0.3 D range.
The Film is slightly overdeveloped because the value of control Gamma has increased from 1.48 to 1.52 while the Speed has changed from 26 to 24.
The density range of the Film with its 0.61 δD value is lower than the optimal according to the need of analog or digital processing.

GENERAL QUALIFICATION:The Film is Unsuitable quality ,
because the horizontal sight is less than 3-times of the flight height,
because the density range is lower than 0.8 δD,
because the LogE range is lower than 0.6.

Székesfehérvár 14.3.1992.

AIRPHOT Expert System