MICRO-MAGICS: METEOROLOGICAL GRAPHICS ON MICROCOMPUTERS

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ABSTRACT

The MICRO-MAGICS software system is described. This software is an adaptation of the MAGICS/GKS software system from ECMWF for meteorological charts plotting in the micro-computer environment, and includes a user-friendly interface and an animation module. The main functions of MICRO-MAGICS are described, as well as the implementation issues faced. A discussion on some future aspects of MICRO-MAGICS closes the paper.

1. INTRODUCTION

The use of microcomputers for graphics and imaging tasks is growing rapidly in recent years, due to the rapid evolution in performance and peripherals of such equipment. A growing number of software facilities previously available only in mainframes are being ported to microcomputers. This paper presents one such system.

ECMWF has developed a meteorological application software system called MAGICS (Meteorological Applications Graphics Integrated Colour System), which is responsible for a major portion of the general meteorological graphics applications at ECMWF (Daabeck et al, 1989). The MAGICS system runs on various computers, in particular the CRAY X-MP and VAX 8350 series computers available at ECMWF.

A natural step for MAGICS would be to install this system (or part of it) in a microcomputer environment. This was made possible by an agreement between ECMWF and CPTEC. CPTEC (Centre for Weather Prediction and Climate Studies) is a Numerical Weather Prediction facility that is being established at Brazil, under the Institute for Space Research (INPE) of Brazil's Ministry of Science and Technology. CPTEC is responsible for providing operational global and regional numerical weather forecasting for the whole country, and for conducting research activities.

In February 1988, INPE/CPTEC and ECMWF concluded an agreement providing for the transfer of MAGICS to a standard microcomputer environment. CPTEC is responsible for making the adaptation, with technical assistance for ECMWF.

This paper describes the MICRO-MAGICS system. First, a brief overview of MAGICS and its relationship to MICRO-MAGICS is given, followed by an overall description of the latter. Some implementation-specific topics are also described and finally, some thoughts on the future of MICRO-MAGICS are given.

2. MAGICS AND ITS RELATION TO MICRO-MAGICS

The MAGICS software system was designed to support the needs of an operational NWP centre, and includes a list of facilities for 2-D plotting of fields and observations. It is based on new meteorological and graphics standards: GRIB, BUFR, CGM and GKS.

The MAGICS system consists of a small set of FORTRAN-callable subroutines which permits the plotting of contours, observations, wind fields (flags, arrows, streamlines and isotachs), text and legend.

Important features of MAGICS (Daabeck et al, 1989) include:

- comprehensive list of simple English language parameters;
- extensive use of colour;
- selection of geographical area and direct projection of data;
- high quality contouring based on CONICON (Sibson and Thomson, 1981);
- shading between contour lines;
- storage of program context;
- device independence, by use of GKS and metafiles.

The MICRO-MAGICS product has the following characteristics:

- The essential functionality of MAGICS is maintained in the micro-computer environment;
- An interactive layer is built on top of the MAGICS software (which operates on batch mode), making it user-friendly.

3. CHARACTERISTICS OF MICRO-MAGICS

3.1 DESIGN GOALS

MICRO-MAGICS was designed with the following user perspective in mind:

- The user is a meteorologist, operating a micro-computer, who may be doing research or operational work.
- The environment consists of a IBM-PC or compatible, using the MS-DOS operating system, with a standard EGA graphics board.
- The data is composed of observations, fields or graphical plots on standard formats, already resident on the micro-computer.

MICRO-MAGICS supposes that the typical user is interested in a sequence of plots, on some previously defined set of conditions (parameters). He would select a sequence of fields (and/or observations) for examination, establishing what graphical function and geographical area is desired for each field.

As each plot is generated on the screen, the user may save it for creating an animation sequence, and for plotting on other graphical devices. In the first case, a slide is created, and in the second, a chart is generated. After a sequence of slides is generated, the user may view them in a carousel-like fashion.

3.2 INPUT AND OUTPUT

MICRO-MAGICS accepts, as input, meteorological fields and observations in the standard GRIB and BUFR formats, respectively. If the user's data is not on the accepted format, the system will enable the conversion from a rectangular array of grid point values to GRIB format.

The outputs of the system are charts shown on the screen or metafiles for interchange to another system, on the standard CGM format. The system will also accept meteorological charts, already stored as CGM metafiles for plotting.

3.3 USER CONTROL

The parameters for executing the actions in MICRO-MAGICS are under complete control of the user. The system will allow for default parameters to be generated for each action.

MICRO-MAGICS enables the storage and retrieval of a set of parameters used to generate the plots. As with MAGICS, this set of parameters is called a specification group_and this mechanism is very useful when making a predetermined sequence of plots or when the user already knows how he wants the output to appear (O' Sullivan, 1987).

4. MICRO-MAGICS ORGANIZATION

4.1 GENERAL

The general format of MICRO-MAGICS is a set of 3 layers, on top of the operating system. The first layer is the interactive layer, which provides a menu-driven interface. The second layer is the Function Layer, which corresponds to the present-day MAGICS functions, suitably adapted for the microcomputer environment. The third layer is the GKS graphic support software.

4.2 INTERACTIVE LAYER

The interactive layer is composed of 4 command menus:

- The DATASEL menu, where the input data are chosen.
- The VIEW menu, where the graphical output is controlled.
- The PARAMETER menu, where the user may inspect and modify the parameter values of the specification groups currently in use.
- The UTILITIES screen, where general book-keeping and maintenance functions will be executed.

The DATASEL option enables the user to select the variables he wants to visualize. He may choose from: GRIB-encoded fields, BUFR-encoded observations, charts (archived as metafiles) and carousels (animation sequences.

To each field/observation selected, the user must attach a specification group, which will contain a number of parameters that control the graphical functions.

The options available at the VIEW menu are: CREATE CHART (a new chart is created and shown to the user); VIEW CHART (a chart - already created - is viewed); CONTROL CAROUSEL (editing of a sequence of slides); ANIMATE (animate the sequence of slides selected by the user).

The user also has some commands which control the graphical output: zoom, fit and activate (grid lines, coastlines and text).

The PARAMETER menu enables the control of the parameters used to generate the plots. As a general rule, the user will modify the parameters for each specification group chosen previously at the DATA SEL menu.

The UTILITIES menu contains general facilities, such as: transforming a simple array into a GRIB file, listing of the specification groups and the creation of new specification groups.

A more detailed description of the interface is given on a companion paper, "Developing an Interactive Interface for MICRO-MAGICS".

4.3 FUNCTION LAYER

4.3.1 GRIB FILES DECODING

GRIB decoding is used in MICRO-MAGICS, in two different manners:

- To sort out the GRIB files resident at the user's directory, thus creating a temporary description file;
- To return complete decoded GRIB fields as internal arrays.

4.3.2 BUFR DATA DECODING

MICRO-MAGICS allows for the plotting of all observation types (SYNOP, AIREP, SATEM, SATOB, DRIBU, TEMP and PILOT).

When BUFR decoding routines are made available as part of MAGICS, they will be converted to MICRO-MAGICS, and will work in a similar fashion to the GRIB ones.

4.3.3 MAPPING

As with MAGICS, MICRO-MAGICS generates plots in cylindrical and polar-stereographic projections, and allows the user to select the desired geographical area.

MICRO-MAGICS also allows the plotting of the world coastlines (in a simplified fashion).

4.3.4 CONTOURING AND SHADING

The isolines are calculated in the latitude/longitude coordinate space and then projected, in the same way as MAGICS. However, due to processing limitations, the contouring procedure in MICRO-MAGICS does not use the CONICON contouring algorithm. The method used is a linear one, with a smoothing procedure proposed by Akima (1970).

The shading procedures available in Micro-MAGICS include dot and solid shading. In the first case, shades of varying dot densities may be chosen.

4.3.4 WIND FIELDS

Wind fields in MICRO-MAGICS (as in MAGICS) may be plotted in four different ways: wind arrows, wind flags, streamlines and isotachs. A particularly useful type of chart is one where the wind information is combined with a temperature field; in this case, the colour of the arrow is determined by a slicing in temperature.

5. IMPLEMENTATION ISSUES IN MICRO-MAGICS

5.1 MEMORY SIZE

The single most important problem faced when translating MAGICS to a micro-computer environment was memory size. The organization of MAGICS gives rise to a single program, with a number of subroutines (some called explicitly by the user and others called internally).

The MAGICS library alone has a 840 Kbytes object code size, making it impossible that a single executable module would contain MICRO-MAGICS in a 640 Kbytes memory PC. Therefore, it was necessary to divide MICRO/MAGICS into a set of executable modules, which are the following:

- COMMAND PROCESSOR : contains all the interactive parts with the exception of the visualization module.

- VISUALIZATION: the meteorological charts visualization module.

- ANIMATION: the animation module.

- MICRO-MAGICS actions and pseudo-actions: GRIB and BUFR decoding, contouring, shading, and wind field, streamlines and isotachs plotting. Each function makes up an executable module.

It was necessary to devise an internal metafile format for data exchange among the modules, which is similar to a CGM one.

The maximum meteorological field size to be shown by Micro-MAGICS was then reduced to a 120 x 61 grid, which corresponds to a global field at 3 x 3 degrees, or to a local area (25 % of the globe) at the 1.5 x 1.5 degree resolution. If the field size to be plotted exceeds these limitations, it will be sampled until the size meets the maximum size. This means that a regular 240 x 121 grid will be reduced by half and that a gaussian 320 x 161 will be sampled by one-third.

5.2 VISUALIZATION AND GKS

When developing MICRO-MAGICS, a problem was detected with the GKS implementation originally intended for use (GKS-GRAL). Although completely satisfactory in terms of functionality, this product has very large memory requirements, and simple programs using it easily surpass 400 kBytes in executable code size. It was therefore impossible to use the GKS-GRAL implementation for the action modules. The alternatives chosen were:

- For the action modules, a reduced output system was implemented, using the same GKS primitives, with output only to a MICRO-MAGICS metafile. This "mini-GKS" is very small and is used by all action modules, leaving more memory free for graphics code. This data is read in the VISUALIZATION module and shown to the user.

- Under CPTEC request, the Image Processing Department of INPE agreed to develop a GKS implementation which supports the functionality needed in MICRO-MAGICS. This GKS implementation has been implemented using modern software engineering principles of abstract data types (Camara et al., 1987) and has been kept to a small size.

5.3 GRIB DATA INPUT

Due to the performance limitations of microcomputers, GRIB data will not be accepted in MICRO-MAGICS in spherical harmonics format. It is expected, however, that all of the other current formats are handled.

The GRIB files accepted as input must comply to some constraints (which are supported by ECMWF archival and retrieval system):

* The reference time of data (as defined in Section 1, Octets 13-17 of GRIB format) for all GRIB fields on a given GRIB file is the same. The time-sequence will be given by the time range indicators (Section 1, Octets 19-21);

* The fields are archived in a ordered growing time-sequence;

* The order of appearance of the meteorological variables must be kept constant within a given GRIB file, for a time-sequence;

* The variables for computing wind fields (U and V) must come together and with the former variable preceding the latter.

6. MILESTONES AND FURTHER DEVELOPMENTS

The first version of MICRO-MAGICS is expected to be available in the first quarter of 1988, and it is equivalent to the current MAGICS/GKS implementation from ECMWF. Further enhancements to MICRO-MAGICS include two lines of development: functionality_and_environments.

It is envisaged that the second version of MICRO-MAGICS will include further functions, especially support for images and thermodynamic diagrams. In the first case, MAGICS/GKS does not handle images, but MICRO-MAGICS has already been organized, aiming at a future extension to handle images. For animation purposes, the graphical charts could be plotted together with images, and saved to build a slide.

In case of environments, some possible options are:

- PCs: the PC performance range has expanded, with the introduction of 80386-based machines and OS/2 operating system.

- Workstations: a common path for both MAGICS and MICRO-MAGICS is the migration to a UNIX-based environment, using such industry standards as X-Windows. A possibility would be to adapt the user interface already available for MICRO-MAGICS and to add the functionalities of MAGICS absent from the PC environment.

- Peripherals: graphics and imaging boards for Pc are becoming widespread, with a large span in capabilities and performance. In particular, CPTEC will have MICRO-MAGICS running an imaging board developed at INPE (1024 x 1024 pixels x 8 bits). It is worthwhile investigating the possibility of running MICRO-MAGICS directly on the new graphics CPUs, such as the Texas Instruments GSP 34010/34020 line of processors. This type of processors have a specialized graphical instruction set besides the more general instructions. One such board is being developed at INPE and there are many commercially available ones.

7. CONCLUSION

The MICRO-MAGICS system is a demonstration of the versatility of the microcomputer environment, in that a product originally developed for a CRAY X-MP computer has been successfully adapted to a low-end (and low-cost) processor.

Since MICRO-MAGICS is based on a very common and cheap environment, and offers a fairly large functionality, it is expected to be used by a large community. In Brazil, it is envisaged that MICRO-MAGICS workstations will receive NWP results (and graphic metafiles) and generate meteorological plots locally.

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