1 Introduction

\LaTeX{} provides a basic but limited picture drawing capability. EPIC\textsuperscript{1} is an enhancement to the picture environment of \LaTeX{} which provides a simpler and more powerful interface. It introduces new commands for drawing solid lines, dotted lines, dash lines and new environments suitable for plotting graphs.

However, EPIC still inherits many of the limitations of \LaTeX{} in picture drawing and hence some of the functions either take a long time to accomplish or the output is not very nice looking.

tpic is preprocessor program for use with \TeX{}. It uses a set of \texttt{\specials} graphics commands for drawing pictures. More and more DVI driver programs supports those specials. They are becoming a standard set of \texttt{\specials} for DVI files. However, the major disadvantage of tpic is that the tpic preprocessor itself is not readily available on most machines. It is written in yacc and C language. It is mainly for UNIX or similar system.

EEPIC, as an extension to both \LaTeX{} and EPIC, tries to alleviate some of the limitations in \LaTeX{}, EPIC and tpic by generating tpic \texttt{\specials} using \TeX{} commands instead of any preprocessor program, but at the same time provides compatibility with the original commands such that when a DVI driver which understands tpic \texttt{\specials} are not available, the documents can still be formatted using standard \LaTeX{} and EPIC. However, the output probably will not be as good as originally intended.

Currently, EEPIC extends \LaTeX{} and EPIC in the following ways:

- Draws lines in any slopes.
- Draws circles and discs (filled circle) in any radii.
- Draws dotted lines and dash lines in a much faster way and requires much less \TeX{} internal memory.
- Provides more line thickness options.

\textsuperscript{1}EPIC is a \LaTeX{} macro package written by Sunil Podar at S.U.N.Y at Stony Brook. Please read the section on installation for more information.
Furthermore, eepic introduces several new commands for:

- drawing of ellipsis and filled ellipsis
- drawing of arcs
- drawing of splines (cubic splines using control points)
- drawing of polylines

All the affected commands in \LaTeX and eepic will be discussed in the subsequent sections. The compatibility issues will be described in the section 7.

In version 1.1, several bugs are fixed, and several commands for area filled are added.
2 Extension to \LaTeX

In \LaTeX, drawing of lines and circles are done using special fonts. Therefore only limited functions are provided. The extensions in \texttt{eepic} allow users to draw lines in any slope and to draw circles in any sizes. However, the limitation of slopes for vectors remains the same in the mean time. That is the slope that can be handled is $\frac{x}{y}$ where $x$ and $y$ are integers in the range $[-4, 4]$. Please read \LaTeX\ manual for details.

2.1 \texttt{\textbackslash line}

The syntax of \texttt{\textbackslash line} is the same as that in \LaTeX:

\begin{verbatim}
\texttt{\textbackslash line}(x, y)\{length\}
\end{verbatim}

But now $x$ and $y$ can be any integer values within the limit of \TeX. Furthermore, there is no more lower limit for \texttt{length} parameter.

2.2 \texttt{\textbackslash circle}

The syntax of \texttt{\textbackslash circle} is the same as that in \LaTeX:

\begin{verbatim}
\texttt{\textbackslash circle}\{diameter\}
\end{verbatim}

or

\begin{verbatim}
\texttt{\textbackslash circle*}\{diameter\}
\end{verbatim}

But now the \texttt{diameter} parameter can be any number acceptable by \TeX\ and a circle with the specified diameter (exactly) will be drawn.

2.3 \texttt{\textbackslash oval}

The \texttt{\textbackslash oval} command is changed such that the maximum diameter of the quarter circles at the corners can be set to any values. This is done by setting the variable \texttt{\maxovaldiam} to the desire \TeX\ dimension. The default is 40pt.
3 Extension to EPIC

EPIC is an enhancement to the Picture Environment of \LaTeX. EPIC generates standard DVI files and requires only standard \LaTeX fonts. Some of the functions it provides are:

\begin{verbatim}
\multiputlist \dottedline \putfile
\matrixput \dashline
\grid \drawline
\end{verbatim}

Details can be found in the EPIC manual.

Extensions to EPIC in \eEPIC include better line drawing output, faster operation and less memory requirement. The commands affected are:

1. \drawline
2. \dashline
3. \dottedline

And the three “*join” environments are indirectly affected also.

3.1 \drawline

The syntax of \drawline is:

\begin{verbatim}
\drawline[stretch](x_1, y_1)(x_2, y_2)\ldots(x_n, y_n)
\end{verbatim}

where \textit{stretch} is an integer between $-100$ and infinity. However any number greater than 0 are the same. An negative \textit{stretch} in \drawline will call \dashline.

The thickness of the line is affected by \thinlines, \thicklines and \Thicklines declarations. Horizontal and vertical lines are drawn using rules.

3.2 \dottedline

The syntax of \dottedline is:

\begin{verbatim}
\dottedline[dot character]{dotgap}(x_1, y_1)(x_2, y_2)\ldots(x_n, y_n)
\end{verbatim}

where \textit{dot character} is the character used in drawing the “dotted” line. \textit{dotgap} is the interdot gap in terms of \unitlength. \specials will only be generated if no optional dot character is specified.

The size of the dots are affected by \thinlines, \thicklines and \Thicklines declarations.

3.3 \dashline

The syntax of \dashline is:

\begin{verbatim}
\dashline[stretch]{dash-length}[inter-dot-gap](x_1, y_1)(x_2, y_2)\ldots(x_n, y_n)
\end{verbatim}

where \textit{stretch} is an integer between $-100$ and infinity. If \textit{inter-dot-gap} is not specified, dashes are drawn in solid lines, otherwise, dashes are drawn using dotted lines.

The thickness of the line is affected by \thinlines, \thicklines and \Thicklines declarations.
New Commands

EPIC introduces a number of new commands. Except the \texttt{path} commands, all other new commands do not have any equivalents in \LaTeX{} and EPIC. Please read section 7 about the compatibility issues.

4.1 \texttt{\textbackslash allinethickness}

Set the line thickness of all line drawing commands including lines in any slopes, circles, ellipsis, arcs, ovals and splines. Note there are only two ‘l’ in the command. The syntax is:

\texttt{\textbackslash allinethickness\{dimension\}}.

4.2 \texttt{\textbackslash Thicklines}

The syntax is:

\texttt{\textbackslash Thicklines}

With the \texttt{\textbackslash Thicklines} declaration, thickness of lines drawn will be about 1.5 times of \texttt{\textbackslash thicklines}.

4.3 \texttt{\textbackslash path}

\texttt{\textbackslash path} is a fast version of \texttt{\textbackslash drawline}. Optional \textit{stretch} argument is not allowed and so it always draw solid lines. The syntax is:

\texttt{\textbackslash path(x_1,y_1)(x_2,y_2)\ldots(x_n,y_n)}

\texttt{\textbackslash path} is mainly used in drawing complex paths.

4.4 \texttt{\textbackslash spline}

Syntax of \texttt{\textbackslash spline} is the same as \texttt{\textbackslash path}.

\texttt{\textbackslash spline(x_1,y_1)(x_2,y_2)\ldots(x_n,y_n)}

\texttt{\textbackslash spline} draws an Chaikin’s curve which passes through only the first and last point. All other points are control points only.

4.5 \texttt{\textbackslash ellipse}

The command \texttt{\textbackslash ellipse} draws an ellipse by specifying the x-diameter and y-diameter.

\texttt{\textbackslash ellipse\{x-diameter\}\{y-diameter\}}

or

\texttt{\textbackslash ellipse*\{x-diameter\}\{y-diameter\}}

When \texttt{x-diameter} is equal to \texttt{y-diameter}, the command is equivalent to \texttt{\textbackslash circle} or \texttt{\textbackslash circle*}. 
4.6 \arc

\arc draws an circular arc. The syntax is

\arc{diameter}{start-angle}{end-angle}

diameter is specified in \unitlength and both start-angle and end-angle are in radian. start-angle must be within 0 and 2\pi and end-angle can be any value between start-angle and start-angle + 2\pi. Arcs are drawn in clockwise direction with angle 0 pointing to the right on the paper.

4.7 \filltype{....}

The command specifies the type of area fill for \circle* and \ellipse*. The command itself does not draw anything. It only changes the interpretation of * in the two commands specified above. The syntax of the command is:

\filltype{area-fill-type}

The legal area fill type are:

- black (default)
- white
- shade

For example, to change area fill type to white fill, the following command should be used.

\filltype{white}

These commands are only intended for advance users (those who know what they are doing). They are included mainly because fig2epic\textsuperscript{2} generate these commands. The commands are:

<table>
<thead>
<tr>
<th>commands</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\blacken</td>
<td>Black fill the next figure</td>
</tr>
<tr>
<td>\whiten</td>
<td>White fill the next figure</td>
</tr>
<tr>
<td>\shade</td>
<td>Shade the interior next figure</td>
</tr>
<tr>
<td>\texture</td>
<td>Specify the pattern used for the next shade command. The pattern will remain effective until it is changed by another \texture command. The syntax is:</td>
</tr>
</tbody>
</table>

\texttt{\texture{ 32 32-bit hexadecimal numbers}}

An example (the default) is:

\texttt{\texture{cccccccc 0 0 0 ccccccccc 0 0 0 ccccccccc 0 0 0 ccccccccc 0 0 0 ccccccccc 0 0 0}}

\textsuperscript{2}Another program written by me to convert Fig output file to eepic format.
The exact interpretation of the above commands are probably device driver dependent. I did most of tests using *iptex* (imagen1) and several tests using *dvips*. The description below may not apply to other device drivers.

The commands that can be specified after \texttt{\blacken}, \texttt{\whiten} and \texttt{\shade} include \texttt{\path}, \texttt{\circle} (without *), \texttt{\ellipse} (again without *) and \texttt{\arc}. The drawings do not have to be closed. The imagen printer will automatically draw an imaginary line from the starting point to the end point, and then fill the figure. When using *iptex*, the outline of the figures are drawn but not in *dvips*. In another words, when using *iptex*, the command:

\begin{verbatim}
\shade\circle{10}
\end{verbatim}

will draw a circle will the circumference in solid line and the interior is filled in the pattern active at that time. However, when using *dvips*, the circle will not have the circumference drawn in solid line.
5 Examples

I shamelessly stole two examples from the EPIC manual so that you can compare the results. The third and fourth examples are created by FIG and then converted to EEPIc using fig2epic which is also written by me.

5.1 Example 1

Figure 1: An example of Various Line Drawing Commands
5.2 Example 2

Figure 2: Test Sample: Lines of various slopes with thinlines
5.3 Example 3

Figure 3: The finite automaton to detect occurrences of $P='AABC'$.

5.4 Example 4

Figure 4: Breath-first search beginning at A
6 Bugs

- The \texttt{circle*} and \texttt{ellipse*} may not work on all DVI drivers especially some previewers. If you have any problem, you should remove the related code in eepic.sty and use the \LaTeX \texttt{circle*} commands. To find the related codes, search for \texttt{special{bk}} in the file.

- The alignment of the quarter circles and the lines in \texttt{oval} command may not be correct on all printers because the command relies on the precise interpretation of the tpic specials which are not defined clearly. If you have any problem, you should either fixed that by changing the position of the quarter circles or remove the whole extended \texttt{oval} command from \texttt{eepic.sty}.

- The area fill commands probably will not work on most previewers, and different device drivers may produce slightly different results.

7 Compatibility

If you want your \TeX file to be compatible with \LaTeX and \texttt{epic} but at the same time you want a better print out by using \texttt{eepic}, you must avoid several features in \texttt{eepic}.

- Try not to use \texttt{line} commands and use \texttt{drawline} instead because \texttt{line} in \LaTeX only supports a limited set of slope.

- Do not use \texttt{arc} command. Use \texttt{ spline} if a curve is really necessary.

- Avoid using solid or small inter-dot gap in drawing long dash lines. They used up a lot of \TeX memory in original \texttt{epic}. You should use \texttt{ drawline} with negative stretch to draw the dash lines.

If you want to use any of the extended commands in \texttt{eepic}, you must include the \texttt{eepic} emulation macros (\texttt{eepicemu}) in the file. The extended commands are emulated in the following ways.

- Circles larger than 40pt will be drawn using \texttt{oval}.

- Ellipsis will be drawn using \texttt{oval}.

- Spline will be approximated by \texttt{drawline}.

- \texttt{path} will be substituted by \texttt{drawline}.

- \texttt{Thicklines} will be substituted by \texttt{thicklines}.

- \texttt{allinethickness} will be substituted by \texttt{thicklines} and \texttt{linethickness}.
8 Installation

There are two possible ways of installing EEPIC. If your DVI printer driver program supports the tpic specials, you should use the standard \texttt{epic.sty} file. If your DVI printer driver does not support the tpic specials or you want to generate a standard DVI file without any special commands, you should use the file \texttt{eepicemu.sty}.

EEPIC is available on \texttt{cs.rochester.edu} and \texttt{sun.soe.clarkson.edu} for anonymous ftp and e-mail request.

8.1 Use tpic Specials

First of all, you have to put a copy of \texttt{epic.sty} and \texttt{eepic.sty} in a place where \LaTeX can find it. See section 4 of EPIC manual for more information.

Both EPIC and EEPIC have been implemented as document style options \texttt{epic} and \texttt{eepic}. When using \texttt{epic} and \texttt{eepic}, \texttt{eepic} must come after \texttt{epic} in the \texttt{\documentstyle} command. For example:

\begin{verbatim}
\documentstyle[epic,eepic]{article}
\end{verbatim}

If you only need the extended \LaTeX commands and the new EEPIC commands, you may include only \texttt{eepic} in the \texttt{\documentstyle} command. But then the EEPIC emulation package will not work. I strongly recommend you to use EEPIC with EPIC all the time.

8.2 No tpic Specials

If you want to get a standard DVI file but you need the extended EEPIC commands, you should rename \texttt{eepicemu.sty} to \texttt{eepic.sty} and put that in a place where \LaTeX can find it. Remember \texttt{\arc} command is not supported and the output will not be as good as standard EEPIC. Furthermore, you cannot use the emulation package with \LaTeX alone. You have to include \texttt{epic} also.