Creating Flowcharts in LaTeX Using the *pic* Language *

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1 Introduction

This tutorial document explains how to create flowcharts in LaTeX using the *pic* language developed by Brian W. Kernighan for typesetting graphics [1]. The *pic* language provides an easy and flexible way to create procedural box-and-arrow diagrams, state flow charts, circuit layouts and other drawings involving repetitive uses of simple geometric forms and splines. The illustrations produced with *pic* can be easily included in *troff* and LaTeX documents. An important advantage of using *pic* is that the figures are in vector form rather than bitmaps, thus can be scaled and stored in compact files without altering the quality of the graphs.

The purpose of this to quickly get you on the right track to producing flowcharts that can be included in LaTeX documents using. This document is not intended to serve as a *pic* tutorial, but it provides references to the documentation where you may find elementary examples, sample pictures, and other details that your are encouraged to check if you are unfamiliar with the *pic* language.

2 Steps to Create Flowcharts and Other Graphs with *pic*

The steps can be summarized in:

1. Write a description of your figure or flowchart using the *pic* language.

2. Convert your *pic* diagram into either of:

   (a) Code containing *PSTricks* commands by executing the *dpic* interpreter as follows:

*Document revision 2. (First version, July 16th, 2001).

```
dpic -p fig.pic > fig.tex
```

(b) Code containing *tpic* `\special` commands by executing the *GNU pic* interpreter as follows:

```
gpic -t fig.pic  > fig.tex
```

or

```
pic -t fig.pic > fig.tex
```

if a newer version of *groff* is installed in your system.

IMPORTANT: When processing the `*.pic` files provided with this document, the variable pstricks in the `*.pic` files must be set to 0 if `gpic` is used or to 1 when `dpic` is used.

3. Depending on whether `gpic` or `dpic` were used in the previous step, include `fig.tex` in your document respectively as follows:

(a)
```
\begin{document}
...
\begin{figure}[htbp]
{
\input fig.tex
\centerline{\box\graph}
}
\caption{Figure title.}
\label{fig_label}
\end{figure}
...
\end{document}
```

(b)
```
\begin{document}
\usepackage{pstricks}
...
\begin{figure}[htbp]
{
\centering
\input fig.tex
}
\caption{Figure title.}
\label{fig_label}
\end{figure}
...
\end{document}
```

The next sections briefly explain where to find the information and tools to accomplish steps 1 and 2. Step 3 should be pretty straight forward as may be seen from the source code for the inclusion of this document's figures (see file `flowchart.tex`).

3 Drawing Flowcharts with *pic*

Making figures with *pic* is well described in the following documents that are available on Internet:

[1] B. W. Kernighan. *PIC – A Graphics Language for Typesetting* (Revised User Manual) Bell Labs Computing Science Technical Report #116, December 1991. Available at:
`http://www.cs.bell-labs.com/10thEdMan/pic.pdf`.
→*This is the classic pic manual and a "must read".*

[2] E. S. Raymond. *Making pictures with GNU PIC*, 1995. In GNU*groff* source distribution.
→*This is a more complete pic manual. See reference [5] at the end of this document for information on where to get the groff package.*

[3] J. D. Aplevich. *M4 Macros for Electric Circuit Diagrams in LaTeX Documents*, version 6.4, 2008. Available at:
`http://texcatalogue.sarovar.org/entries/circuit-macros.html` or the Comprehensive TeXArchive Network (CTAN, `http://www.ctan.org`) mirrors.
→*This document is about the LaTeXpackage* `circuit-macros`*, which is based on M4 macros and pic. This package contains an excellent collection of PIC macros for many circuit components and other schematic diagrams blocks. It is a "must read" because it provides a good set of references and a concise explanation about the methodology to create pic drawings using the* `gpic` *or* `dpic` *interpreters. The* `circuit-macros` *documentation played a key role in the preparation of this tutorial and the flowchart macros and examples.*

[4] J. D. Aplevich. *Dpic package*, version 29 Oct. 2008. Available at:
`http://www.ece.uwaterloo.ca/ aplevich/dpic/`.
→*Read the README and the MAN file (manual) for more information on the* `dpic` *interpreter.*

[5] *Groff* for Windows, version 1.19.2. Available at:
`http://gnuwin32.sourceforge.net/packages/groff.htm`.
The package homepage is:
`http://www.gnu.org/software/groff/groff.html`.
→*Read the MAN file (manual) of* `gpic` *(also known as* `pic`*) for more information on* `gpic`*, the GNU pic interpreter.*

There is no point in repeating the good explanations found in these references. If you are unfamiliar with *pic* and cannot figure out the meaning of the drawing commands in the `*.pic` files provided as examples with this document, you should read the references in the order in which they have been listed to get a good basis of *pic*'s capabilities and functionality.

Creating flowcharts with *pic* is not much different to the process of making a figure with *pic*. To facilitate the task of making flowcharts, a set of macros for the standard flowchart symbols was created (see Appendix A or the `*.pic` files for details on the macro definitions). In order to make your own flowcharts you must copy the macros from any of the `*.pic` files to a new file and write your code right after the macros. Do not forget to end your code with the `.PE` *pic* command. The structure of your *pic* file should look like:

```
.PS #20/25.4 # Scale drawing to 20/25.4 in =
             #                 =x 20/25.4[in]/25.4[mm/in] = 20 mm
# FLOWCHART - Basic flow chart blocks.

<<< HERE ARE THE MACRO DEFINITONS>>>

#--- END OF MACROS ---

#--- YOUR FLOWHART CODE STARTS HERE ---

<<< PLACE YOUR FLOWCHART CODE HERE>>>

.PE
```

The macros receive as arguments the scaling factors for the horizontal (sx) and vertical (sy) dimension of the symbol. Only the connector symbol receives one scaling factor (s) because it is a circle. The scaling factors multiply the basic unit length defined for the macros as parameter `csize` (cell size). For example, a symbol which is 12×8 units or cells and that has been declared with sx set to 2, sy set to 4, will be 24×32 units big. By default the cell size value is set to 2 mm, therefore, the scaled symbol will actually measure 48×64 mm. The available macros are:

- process(sx,sy): makes a "process" block (rectangle).
- data(sx,sy): makes a "data input or output" block (parallelogram).
- connector(s): makes a connector symbol (circle).
- decision(sx,sy): makes a decision block (rhombus).
- preparation(sx,sy): makes a routine initialization or program preparation block (hexagon-like block).
- sf terminator(sx,sy): makes a terminating block ("flat slim sausage" block).

- keying(sx,sy): makes a block to represent a process or operation that involves typing or is driven by some manual input device ("flat fat sausage" block).
- keyboard(sx,sy): makes a block to represent a keyboard, switches or push-buttons (quadrilateral block).
- document(sx,sy): makes a document symbol (rectangle with wavy line at the bottom).
- display(sx,sy): makes a display symbol to represent a computer screen or monitor, video devices, console printers, or other visual indicators.

The symbols produced by these macros are shown in the figure 1, which was created with the following lines of code (see file `flow0.pic`):

```
down;
C0: connector(1);
arrow;
H0: preparation(1,1); "\sf Preparation" at H0.c;
move to H0.B.s;
arrow;
D0: data(1,1); "\sf Data" at D0.c;
move to D0.B.s;
arrow;
P0: process(1,1); "\sf Process" at P0.c;
move to P0.B.s;
arrow;
R0: decision(1,1); "\sf Decision" at R0.c;
move to R0.B.s;
arrow;
T0: terminator(1,1); "\sf Terminator" at T0.c;

move to R0.B.w;
left;
arrow;
K0: keying(1,1); "\sf Keying" at K0.c;
move to K0.B.w;
arrow invis;
K1: keyboard(1,1); "\sf Keyboard" at K1.c;
move to K1.B.e;
right;
arrow;

move to K0.B.n;
line -> dashed up C0.w.y-K0.n.y then right C0.w.x-K0.n.x;

move to P0.B.e;
```

```
right;
arrow;
W0: document(1,1); "\sf Document" at W0.c;

move to D0.B.e;
right;
arrow;
S0: display(1,1); "\sf Display" at S0.c;
```

It is to be noted that the sizing of the symbols was made according to the IBM flowcharting template [6], in which most symbols are 12×8 units long and should also match those of the ISO standard [7]. Practically any flowchart can be prepared with these symbols. As a matter of fact, the *basic blocks*: process, data, connector, together with the *processing and sequencing symbols*: decision, preparation, terminator, should be sufficient for most flowcharting needs. The *input/output and processing hardware related symbols* can be replaced for data blocks without losx of clarity, as far as the data flow or algorithmic description are concerned.

Additional examples on the use of the macros are presented in the next subsections. For further information and references about flowcharts please check also [8] and references therein.

3.1 Basic Program Flow Structures

Figure 2 shows the basic program flow structures: a simple sequential execution of three process, a conditional branching (If-Then-Else) and a program loop (While-Do loop). These simple flowcharts were generated by the following code (see file `flowbs.pic`):

```
#Sequence
down;
S1: [move down 30;
     arrow;PA: process(1,1); "\sf Process A" at PA.c;
     move to PA.B.s;
     arrow;PB: process(1,1); "\sf Process B" at PB.c;
     move to PB.B.s;
     arrow;PC: process(1,1); "\sf Process C" at PC.c;
     move to PC.B.s;
     arrow;box invis "{\Large {\sf Sequence}}";
    ]
move to S1.ne+(60,0);

#If-Then-Else
I1: [arrow;
     R1: decision(1,1); "\sf Decision" at R1.c;
     move to R1.s;
     arrow;
```

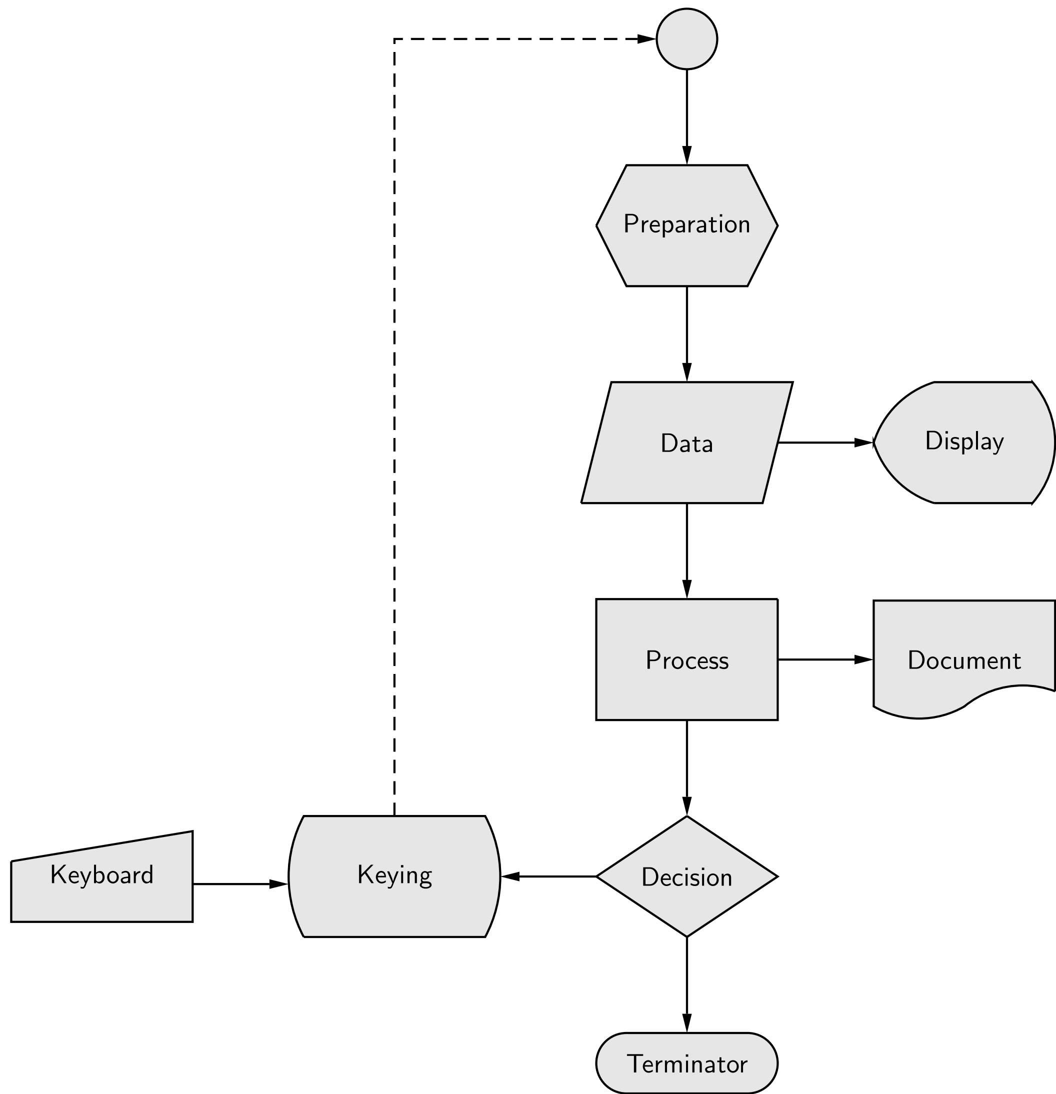

Figure 1: Basic flowchart symbols.

```
     P1: process(1,1); "\sf Process 1" at P1.c;
     move to P1.B.s;
     L1: line;
     move to R1.e; line -> right 20 then down R1.e.y-P1.n.y;
     P2: process(1,1); "\sf Process 2" at P2.c;
     move to P2.B.s;
     line -> down P2.s.y-L1.end.y then left P2.s.x-L1.end.x;
     down;arrow;box invis "{\Large {\sf If-Then-Else}}";
    ]
move to I1.s-(0,5);

#While-Do
W1: [L1: line;
     arrow;
     R1: decision(1,1); "\sf Decision" at R1.c;
     move to R1.s;
     arrow;
     box invis "{\Large {\sf While-Do}}";
     move to R1.e;
     right;arrow;
     P1: process(1,1); "\sf Process X" at P1.c;
     move to P1.n;
     line -> up L1.end.y-P1.n.y then left P1.n.x-L1.end.x;
    ]
```

3.2 Derived Program Flow Structures

There exist two common program flow structures that can be derived from the previous ones. These are the Case-Of, which corresponds to a series of If-Then-Else statements, and the Do-Until loop, which is derived from the While-Do loop. The Do-Until loop is equivalent to *always* executing the code within the While-Do loop at least once before exiting the loop if the condition is not met. Other names for the Do-Until loop are Repeat-Until or the similar Do-While. These derived program flow structures are represented by the flowcharts shown in fig. 3, which was created with the following code (see file `fileds.pic`):

```
#Case-Of
down;
CS1: [arrow;
     R1: decision(1,1); "\sf Decision 1" at R1.c;
     move to R1.s;
     arrow;
     R2: decision(1,1); "\sf Decision 2" at R2.c;
     move to R2.s;
     arrow;
     R3: decision(1,1); "\sf Decision 3" at R3.c;
```

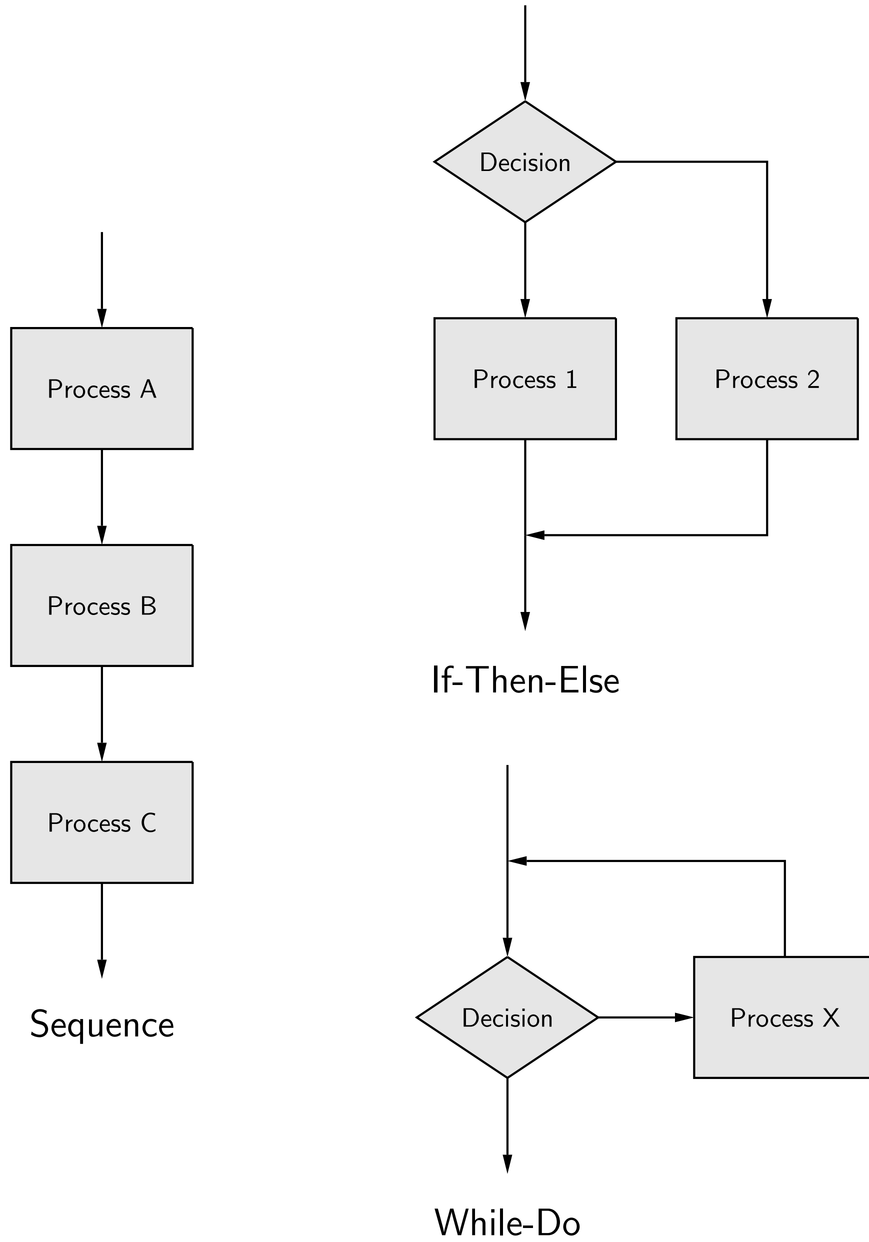

Figure 2: Basic program flow structures.

```
      move to R3.s;
      arrow;
      PD: process(1,1); "\sf Default" "\sf Process" at PD.c;
      move to PD.s;
      L1: line;
      move to R1.e;
      right;arrow;
      P1: process(1,1); "\sf Process 1" at P1.c;
      move to P1.e;
      P1A: arrow;
      move to R2.e;
      right;arrow;
      P2: process(1,1); "\sf Process 2" at P2.c;
      move to P2.e;
      arrow;
      move to R3.e;
      right;arrow;
      P3: process(1,1); "\sf Process 3" at P3.c;
      move to P3.e;
      arrow;
      move to P1A.end;
      line -> down P1A.end.y-L1.end.y then left P1A.end.x-L1.end.x;
      down;arrow;box invis "{\Large {\sf Case-Of}}";
     ]
move to CS1.ne+(40,-35);
#Do-Until
DU1: [L1: line;
      arrow;
      P1: process(1,1); "\sf Process" at P1.c;
      move to P1.s;
      arrow;
      R1: decision(1,1); "\sf Decision" at R1.c;
      move to R1.s;
      arrow;
      box invis "{\Large {\sf Do-Until}}";
      move to R1.e;
      line -> right 20 then up L1.end.y-R1.e.y then left R1.e.x+20-L1.end.x;
     ]
```

3.3 A real example

To illustrate the application of the flowchart macros on a real example, consider the pseudocode of a color-based image segmentation process presented as algorithm 1. For every pixel p in an image, the algorithm computes a color feature $f(p)$ and checks if the feature is within some threshold λ with respect to all the

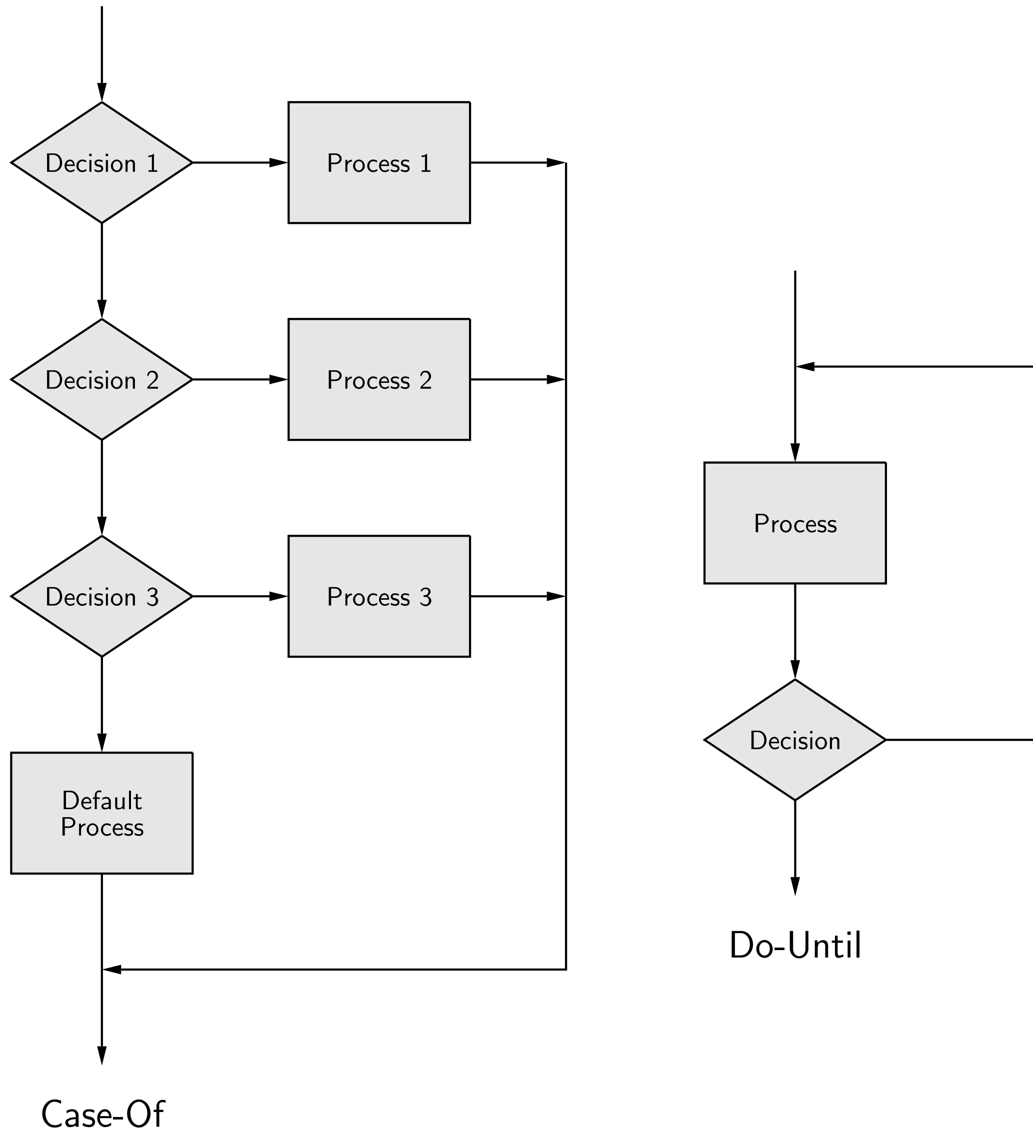

Figure 3: Derived program flow structures.

different classes' reference feature vector f_c. The two outer `for-from-to-do` loops correspond to the pixel position, while the inner loop corresponds to the testing with respect to each class c. This algorithm can be describe in terms of the flowchart shown in fig. 4. In this flowchart example, the two outer `for-from-to-do` loops have been represented by a single `for-from-to-do` loop over the pixel position p.

Algorithm 1: ProcessImage (Low-level Pseudocode)

```
input : &img (input image), &ProcessParam (process parameters)
output: &img (segmented image)

&imgaux ← &img;

—— ComputeSegmentation ——;
for row = 0 to  &img.height do
  | for col = 0 to  &img.width do
  |   | for class = 1 to  &ProcessParam.Nclasses do
  |   |   | if ||ConvertToYCrCb(&imgaux(row,col))...
  |   |   |         −&ProcessParam.FeatureVector(class)|| <Threshold then
  |   |   |    |  &img ← class;
  |   |   | end
  |   | end
  | end
end
```

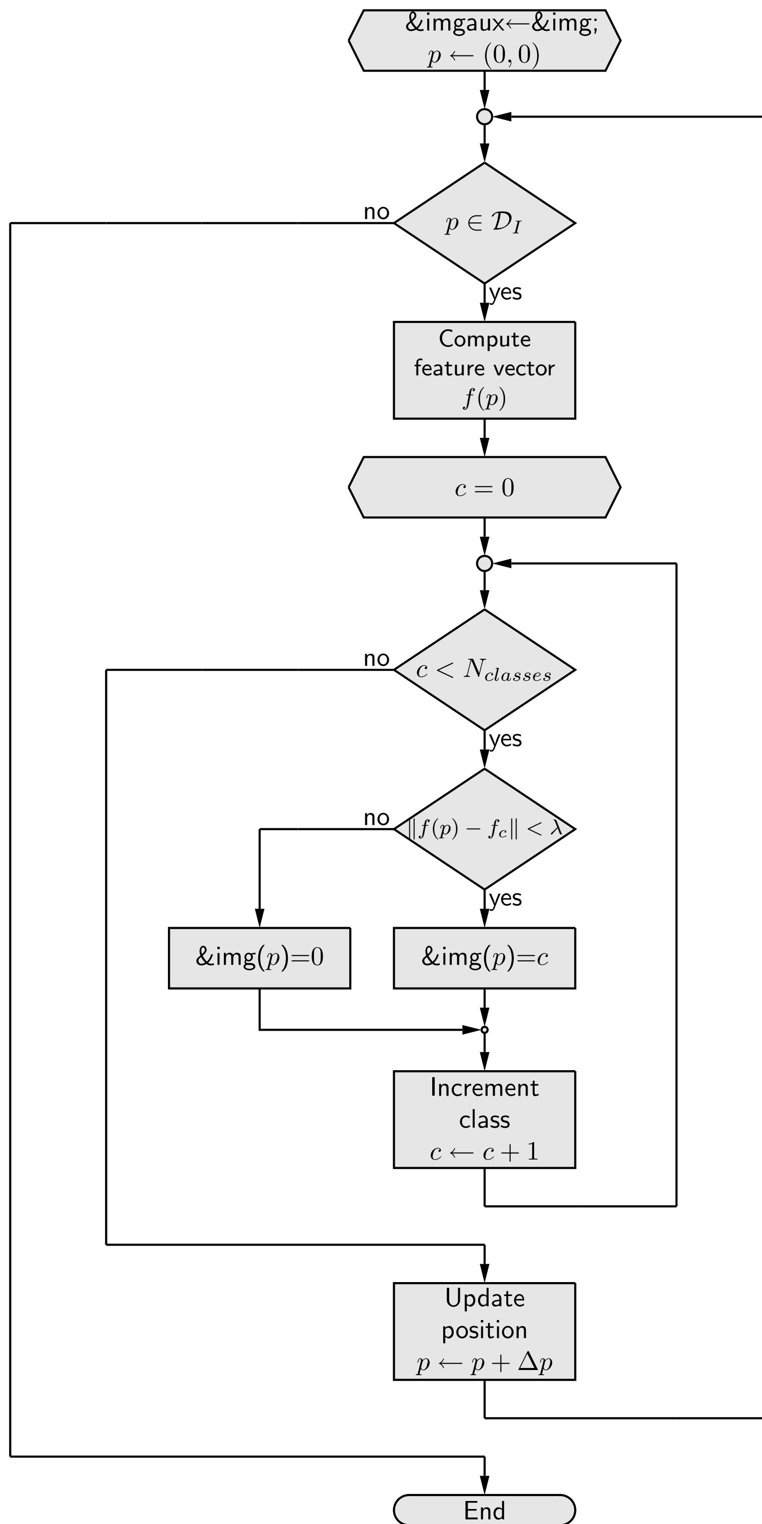

Figure 4: Flowchart for a color-based image segmentation process.

The code that generates de flowchart in fig. 4 is (see file `flowcs.pic`):

```
alen = 25.4/4*0.8; # arrow length
crad = 1/csize/2; # connector radius in csize*2 units

# initialize the for loop on p (p is the pixel position)
down;
H0: preparation(1.5,0.5);
    "\parbox{6em}{\centering \sf \&imgaux$\leftarrow$\&img;\\
                  $p\leftarrow (0,0)$}" at H0.c;
move to H0.B.s;
arrow alen;

C0: connector(crad);
arrow alen;

# check if the for loop on p is done
R0: decision(1,1);
    "\parbox{6em}{\centering \sf $p\in\mathcal{D}_I$}" at R0.c;
move to R0.B.w; "\sf no" above rjust;
move to R0.B.s; "\sf yes" below ljust;
move to R0.B.s;
arrow alen;

P0a: process(1,0.8);
     "\parbox{6em}{\centering \sf \small Compute\\
                   feature vector\\ $f(p)$}" at P0a.c;
move to P0a.B.s;
arrow alen;

# initialize the for loop on c (c is the class label)
H1: preparation(1.5,0.5);
    "\parbox{6em}{\centering \sf $c=0$}" at H1.c;
move to H1.B.s;
arrow alen;

C1: connector(crad);
arrow alen;

# check if the for loop on c is done
R1: decision(1,1);
    "\parbox{6em}{\centering \sf $c<N_{classes}$}" at R1.c;
move to R1.B.w; "\sf no" above rjust;
move to R1.B.s; "\sf yes" below ljust;
move to R1.B.s;
arrow alen;
```

```
# check if the feature at pixel p, f(p) can be classified
# as the class c, due to the proximity with respect to
# the class feature vector f_c
R1a: decision(1,1);
     "\parbox{7em}{\centering \sf
                   \footnotesize $\|f(p)-f_c\|<\lambda$}" at R1a.c;
move to R1a.B.w; "\sf no" above rjust;
move to R1a.B.s; "\sf yes" below ljust;
move to R1a.B.s;
arrow alen;

P1a: process(1,0.5);
     "\parbox{6em}{\centering \sf \&img($p$)=$c$}" at P1a.c;
move to P1a.B.s;
down; arrow alen;
C1e: connector(0.1);

move to R1a.B.w;
left; line; line alen;
line -> down R1a.c.y-P1a.n.y;

P1b: process(1,0.5);
     "\parbox{6em}{\centering \sf \&img($p$)=$0$}" at P1b.c;
move to P1b.B.s;
line -> down P1b.s.y-C1e.c.y then right to C1e.w;

move to C1e.s;
down; arrow alen;
P1: process(1,0.8);
    "\parbox{6em}{\centering \sf Increment class\\
                  $c\leftarrow c+1$}" at P1.c;
move to P1.B.s;
L1a: line alen;

# close for loop on c
move to L1a.end;
right; line; line;
up; line C1.c.y-Here.y;
left; line -> to C1.e;

# end for loop on c
move to R1.B.w;
left; line; line; line;
line down R1.B.w.y-P1.B.s.y+2*alen;
line right P1.B.c.x-Here.x;
```

```
L1b: arrow down alen;

move to L1b.end;
down;
P0: process(1,0.8);
    "\parbox{6em}{\centering \sf Update position\\
                  $p\leftarrow p+\Delta p$}" at P0.c;

# close for loop on p
move to P0.B.s;
line down alen;
right; line; line; line;
line up C0.c.y-Here.y;
line -> left to C0.e;

# end for loop on p
move to R0.B.w;
left; line; line; line; line;
line down R0.B.w.y-P0.B.s.y+2*alen;
line right P0.B.c.x-Here.x;
L0b: arrow down alen;

T0: terminator(1,0.5);
    "\parbox{6em}{\centering \sf End}" at T0.c;
```

4 Compiling *pic* drawings to LaTeX

Processing *pic* code can be done using *dpic* or the *GNU pic* interpreter (*gpic*). The output formats produced by *dpic* and *gpic* are completely different (see Ch. 12 of the `circuit-macros` documentation [3] or the *dpic* manual [4] for a complete description of the multiple formats). The differences can be summarized in:

- *dpic* produces *PSTricks* commands.
- *gpic* produces *tpic* (TeX *pic*) `\special` commands that have to be later processed with a printer driver that understands *tpic* `\special` commands, such as *dvips*.

Depending on the approach chosen and the version of your *dvi* or *Postscript* viewer, the output produced with *gpic* may be correctly displayed only under the *Postscript* viewer (e.g. *gv*, *Ghostview*), but not under the *dvi* viewer (e.g. *Xdvi*, *Yap*). On the other hand, *dpic* requires the *PSTricks* LaTeX package to be installed and included in your LaTeX file, while the output produced by *gpic* does not require the use of any additional package.

As stated in section 2, converting from `*.pic` to `*.tex` can be done using one of the following alternatives:

(a) Using *dpic* [4]:

```
dpic -p fig.pic > fig.tex
```

(b) Using *gpic* [5]:

```
gpic -t fig.pic  > fig.tex
```

or with

```
pic -t fig.pic > fig.tex
```

if a newer version of *groff* is installed in your system.

IMPORTANT: When processing the `*.pic` files provided with this document, the variable pstricks in the `*.pic` files must be set to 0 if `gpic` is used or to 1 when `dpic` is used.

Once the `*.tex` files are produced with any of the two previous methods, the last step is to include them into your LaTeX document according to the corresponding approach, as explained in the third point of section 2 (see also the source code of the examples provided with this document).

References

[1] B. W. Kernighan. *PIC – A Graphics Language for Typesetting* (Revised User Manual) Bell Labs Computing Science Technical Report #116, December 1991. Available at: `http://www.cs.bell-labs.com/10thEdMan/pic.pdf`.

[2] E. S. Raymond. *Making pictures with GNU PIC*, 1995. In GNU*groff* source distribution.

[3] J. D. Aplevich. *M4 Macros for Electric Circuit Diagrams in LaTeX Documents*, version 6.4, 2008. Available at: `http://texcatalogue.sarovar.org/entries/circuit-macros.html` or the CTAN `http://www.ctan.org` mirrors.

[4] J. D. Aplevich. *Dpic package*, version 29 Oct. 2008. Available at: `http://www.ece.uwaterloo.ca/ aplevich/dpic/`.

[5] *Groff* for Windows, version 1.19.2 Available at: `http://gnuwin32.sourceforge.net/packages/groff.htm`. The package homepage is: `http://www.gnu.org/software/groff/groff.html`.

[6] International Business Machines Corporation. IBM Flowcharting Techniques. IBM Technical Publications Dept. Document No. C20-8152-1, New York, 1069. Available at: http://www.fh-jena.de/~kleine/history/software/...
...IBM-FlowchartingTechniques-GC20-8152-1.pdf.

[7] ISO 5807:1985 Standard: Information processing – Documentation symbols and conventions for data, program and system flowcharts, program network charts and system resources charts. Available at: http://www.iso.org/iso/iso_catalogue/catalogue_tc/...
...catalogue_detail.htm?csnumber=11955.

[8] Wikipedia. Flowchart. Visited on December, 17th, 2008. http://en.wikipedia.org/wiki/Flowchart.

Appendix A *pic* Flowchart Macros

The macros implemented to produce the flowcharts in this document were defined as *pic language blocks*. These blocks provide *flowchart primitives* by grouping into a single object or entity the lower level primitives of the *pic* language, such as lines, boxes and arcs. Not surprisingly, the *pic* language primitives grouped to form an object are called *blocks* in the terminology of the *pic* language. The following code shows the implementation of the macros developed to plot the flowchart symbols of the examples presented in this document. The code of these macros should be included at the beginning of your own flowcharts as explained in section 3.

```
.PS #20/25.4 # Scale drawing to 20/25.4 in =
             #               = 20/25.4[in]/25.4[mm/in] = 20 mm
# FLOWCHART - Basic flow chart blocks.
scale=25.4 #Scale units from inches to mm
csize=2.0  #Cell size in mm
pstricks=1
dx=0; dy=2;
#sshade(): Starts shading of an arbitrary closed curve.
define sshade
{
  if pstricks==0 then
  {
   sprintf("\special{sh %g}",0.1)
   #command "\special{sh 0.1}"
  } else
  {
   #sprintf("\newgray{xcolor}{%s}",0.9)
   command "\newgray{xcolor}{0.9}"
   command "\pscustom[fillstyle=solid, fillcolor=xcolor]{"
  }
}
#eshade(): Ends shading of an arbitrary close curve.
define eshade
{
  if pstricks==1 then
  {
   command "}%"
  }
}
define process
{[
  w=$1*12*csize; h=$2*8*csize;
  B: box wid w ht h invis;
  sshade;
```

```
  line from B.ne to B.nw to B.sw to B.se to B.ne;
  eshade;
  #$3 at B.c;
]}
# data(): parallelogram -> "data input/output block"
define data
{[
  w=$1*12*csize; h=$2*8*csize;
  dx=(h/4)/2;
  B: box wid w ht h invis;
  sshade;
  line from B.sw-(dx,0) to B.se-(dx,0) to B.ne+(dx,0)
                        to B.nw+(dx,0) to B.sw-(dx,0);
  eshade;
  #$3 at B.c;
]}
define connector
{[
  r=$1*2*csize;
  sshade;
  B: circle rad r;
  eshade;
  #$3 at B.c;
]}
# decision(): rhomboid -> "if block"
define decision
{[
  w=$1*12*csize; h=$2*8*csize;
  B: box wid w ht h invis;
  sshade;
  line from B.n to B.e to B.s to B.w to B.n;
  eshade;
  #$3 at B.c;
]}
define preparation
{[
  w=$1*12*csize; h=$2*8*csize;
  dx=(h/2)/2;
  B: box wid w ht h invis;
  sshade;
  line from B.w to B.nw+(dx,0) to B.ne-(dx,0) to B.e
                to B.se-(dx,0) to B.sw+(dx,0) to B.w;
  eshade;
  #$3 at B.c;
]}
define terminator
```

```
{[
  w=$1*12*csize; h=$2*4*csize;
  r=h/2;
  B: box wid w ht h invis;
  sshade;
  line from B.sw+(r,0) to B.se-(r,0);
  right; arc rad r from Here to B.ne-(r,0);
  line from Here to B.nw+(r,0);
  left; arc rad r from Here to B.sw+(r,0);
  eshade;
  #$3 at B.c;
]}
define keying
{[
  w=$1*14*csize; h=$2*8*csize;
  dx=(h/4)/2;
  r=dx/2+(h/2)^2/(2*dx);
  B: box wid w ht h invis;
  sshade;
  line from B.sw+(dx,0) to B.se-(dx,0);
  left; arc rad r from Here to B.ne-(dx,0);
  line from Here to B.nw+(dx,0);
  right; arc rad r from Here to B.sw+(dx,0);
  eshade;
  #$3 at B.c;
]}
define keyboard
{[
  w=$1*12*csize; h=$2*5*csize;
  dy=(w/6)/2;
  B: box wid w ht h invis;
  sshade;
  line from B.nw-(0,dy) to B.sw to B.se
                      to B.ne+(0,dy) to B.nw-(0,dy);
  eshade;
  #$3 at B.c;
]}
define document
{[
  w=$1*12*csize; h=$2*7*csize;
  dy=(w/6)/2;
  r=sqrt((w/2)^2+dy^2);
  B: box wid w ht h invis;
  sshade;
  line from B.se+(0,dy) to B.ne to B.nw to B.sw;
  up; arc rad w/2 from B.sw to B.s;
```

```
  arc cw rad r from B.s to B.se+(0,dy);
  eshade;
  #$3 at B.c;
]}
define display
{[
  w=$1*12*csize; h=$2*8*csize;
  dx=1.5*(h/4)/2;
  r=dx/2+(h/2)^2/(2*dx);
  B: box wid w ht h invis;
  sshade;
  line from B.sw+(4*dx/1.5,0) to B.se-(dx,0);
  left; arc rad r from Here to B.ne-(dx,0);
  line from Here to B.nw+(4*dx/1.5,0);
  arc rad r from Here to B.w;
  right; arc rad r from Here to B.sw+(4*dx/1.5,0);
  eshade;
  #$3 at B.c;
]}
#--- END OF MACROS ---
```