Through the looking glass, and what Joseph found there

Joseph Wright

\LaTeX{} Project
The \texttt{xfp} package
Floating Point Unit

The \texttt{LATEX3} Project*

Released 2018-05-12

This package provides a \texttt{LATEX2\epsilon} document-level interface to the \texttt{LATEX3} floating point unit (part of \texttt{expl3}). It also provides a parallel integer expression interface for convenience.

\texttt{fpeval}  

The expandable command \texttt{fpeval} takes as its argument a floating point expression and produces a result using the normal rules of mathematics. As this command is expandable it can be used where \TeX requires a number and for example within a low-level \texttt{edef} operation to give a purely numerical result.

Briefly, the floating point expressions may comprise:

• Basic arithmetic: addition $x + y$, subtraction $x - y$, multiplication $x \times y$, division $x/y$, square root $\sqrt{x}$, and parentheses.
• Comparison operators: $x < y$, $x \leq y$, $x > y$, $x \geq y$ etc.
• Boolean logic: sign $\text{sign}(x)$, negation $\lnot x$, conjunction $x \land y$, disjunction $x \lor y$, ternary operator $x ? y : z$.
• Exponentials: $\exp x$, $\ln x$, $x^y$.
• Trigonometry: $\sin x$, $\cos x$, $\tan x$, $\cot x$, $\sec x$, $\csc x$ expecting their arguments in radians, and $\sin d x$, $\cos d x$, $\tan d x$, $\cot d x$, $\sec d x$, $\csc d x$ expecting their arguments in degrees.
• Inverse trigonometric functions: $\arcsin x$, $\arccos x$, $\arctan x$, $\arccot x$, $\arcsec x$, $\arccsc x$ giving a result in radians, and $\arcsind x$, $\arccosd x$, $\artand x$, $\arccotd x$, $\arccsedd x$, $\arccscd x$ giving a result in degrees.
• Extrema: $\max(x, y, \ldots)$, $\min(x, y, \ldots)$, $\abs{x}$.
• Rounding functions ($n = 0$ by default, $t = \text{NaN}$ by default): $\text{trunc}(x, n)$ rounds towards zero, $\text{floor}(x, n)$ rounds towards $-\infty$, $\text{ceil}(x, n)$ rounds towards $+\infty$, $\text{round}(x, n, t)$ rounds to the closest value, with ties rounded to an even value by default, towards zero if $t = 0$, towards $+\infty$ if $t > 0$ and towards $-\infty$ if $t < 0$.
• Random numbers: $\text{rand}()$, $\text{randint}(m, n)$ (not available in \texttt{XETEX}).
• Constants: $\pi$, $\deg$ (one degree in radians).

*E-mail: latex-team@latex-project.org
The \LaTeX\ 2\epsilon environment

- picture mode
The \LaTeX\ 2\varepsilon environment

- picture mode
- color and graphicx
- pdftex.def, etc.
The \LaTeX\ 2ε environment

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- pgf, TikZ
\LaTeX\ 2\varepsilon \textit{Drivers}
\LaTeX{}3 drivers

\texttt{\%\textasciitilde\textasciitilde\texttt{package}}
\\texttt{\textbackslash ProvidesExplFile}
\texttt{\%\textasciitilde\textasciitilde\texttt{dvipdfmx}}
\texttt{\{}\texttt{l3dvidpfmx.def}\texttt{\{}2018-06-14\}\{}\texttt{\{}\texttt{L3 Experimental driver: dvipdfmx}\texttt{\}}
\texttt{\%\textasciitilde\textasciitilde\texttt{dvipdfmx}}
\texttt{\%\textasciitilde\textasciitilde\texttt{dvips}}
\texttt{\{}\texttt{l3dvips.def}\texttt{\{}2018-06-14\}\{}\texttt{\{}\texttt{L3 Experimental driver: dvips}\texttt{\}}
\texttt{\%\textasciitilde\textasciitilde\texttt{dvips}}
...
2.3.2 Meaning of standard color expressions

We explain now how an expression

\[
\langle \text{prefix} \rangle \langle \text{name} \rangle \langle \text{pct}_1 \rangle \text{!} \langle \text{name}_1 \rangle \langle \text{pct}_2 \rangle \text{!} \ldots \text{!} \langle \text{pct}_n \rangle \text{!} \langle \text{name}_n \rangle \langle \text{postfix} \rangle
\]

is being interpreted and processed:

1. First of all, the model and color parameters of \( \langle \text{name} \rangle \) are extracted to define a temporary color \( \langle \text{temp} \rangle \). If \( \langle \text{postfix} \rangle \) has the form \( \langle \text{num} \rangle \text{!!}[\langle \text{num} \rangle] \), then \( \langle \text{temp} \rangle \) will be the corresponding (direct-accessed) color \( \langle \text{num} \rangle \) from the series \( \langle \text{name} \rangle \).

2. Then a color mix, consisting of \( \langle \text{pct}_1 \rangle \% \) of color \( \langle \text{temp} \rangle \) and \( (100 - \langle \text{pct}_1 \rangle)\% \) of color \( \langle \text{name}_1 \rangle \) is computed; this is the new temporary color \( \langle \text{temp} \rangle \).

3. The previous step is being repeated for all remaining parameter pairs \( \langle \text{pct}_2 \rangle, \langle \text{name}_2 \rangle, \ldots, \langle \text{pct}_n \rangle, \langle \text{name}_n \rangle \).

4. If \( \langle \text{prefix} \rangle \) consists of an odd number of minus signs ‘-’, then \( \langle \text{temp} \rangle \) will be changed into its complementary color.

5. If \( \langle \text{postfix} \rangle \) has the form \( \langle \text{num} \rangle \text{!!}[+], \langle \text{num} \rangle \text{!!}[++] \), \( \langle \text{num} \rangle \text{!!}[+++], \ldots \), a number of step commands (= number of ‘+’ signs) are performed on the underlying color series \( \langle \text{name} \rangle \). This has no consequences for the color \( \langle \text{temp} \rangle \).

6. Now the color \( \langle \text{temp} \rangle \) is being displayed or serves as an input for other operations, depending on the invoking command.

Note that in a typical step 2 expression \( \langle \text{temp} \rangle \text{!} \langle \text{pct}_n \rangle \text{!} \langle \text{name}_n \rangle \), if \( \langle \text{pct}_n \rangle = 100 \)
Model interconversion

- Red–Green–Blue
- Cyan–Magenta–Yellow–black
- Grayscale
- Spot color
Model interconversion

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Interconversion is non-trivial!
Motivation

- ‘Feature complete’ aims of expl3
Motivation

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- API consistency
Motivation

- ‘Feature complete’ aims of expl3
- API consistency
- Exploit expl3 features: the FPU
## Drawing layers

<table>
<thead>
<tr>
<th>Layer</th>
<th>System</th>
<th>Base</th>
<th>Interface</th>
</tr>
</thead>
</table>

## Drawing layers

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>System</td>
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</thead>
<tbody>
<tr>
<td>System</td>
<td><code>\pgfsys@moveto</code></td>
<td><code>\driver_draw_moveto:nn</code></td>
</tr>
<tr>
<td>Base</td>
<td><code>\pgfpathmoveto</code></td>
<td><code>\draw_path_moveto:n</code></td>
</tr>
<tr>
<td>Interface</td>
<td><code>\draw</code></td>
<td>—</td>
</tr>
</tbody>
</table>
\draw_begin:
  \draw_path_corner_arc:nn { 4pt } { 4pt }
  \draw_path_moveto:n
    { \draw_point_polar:nn { 0 } { 1cm } }
  \int_step_inline:nnnn { 72 } { 72 } { 359 }
  {
    \draw_path_lineto:n
      { \draw_point_polar:nn { #1 } { 1cm } }
  }
  \draw_path_close:
  \draw_path_use_clear:n { stroke }
\draw_end:
Integration with expl3 concepts

\draw_begin:
  \draw_path_moveto:n { 0cm, 0cm }
  \draw_path_lineto:n { 0cm, 1cm }
  \draw_path_use_clear:n { stroke }
  \hcoffin_set:Nn \l_tmpa_coffin
    { This~is~text. }
  \draw_coffin_use:Nnn \l_tmpa_coffin { hc } { vc }
\draw_end:

This is text.
Expandable expressions

\tl_set:Nx \l_tmpa_tl
{\draw_point_intersect_circles:nnnnn
  { (0,0) } { 1cm }
  { (sqrt(2),sqrt(3)) } { 1cm }
  { 1 }
}
\tl_to_str:N \l_tmpa_tl
Right arm over, three to come . . .

- Many core pgf functions working
Right arm over, three to come . . .

- Many core pgf functions working
- More driver work still required
Right arm over, three to come . . .

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- Still to do: transparency, objects, etc.
Right arm over, three to come . . .

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- More driver work still required
- Still to do: transparency, objects, etc.
- Perhaps an interface to TikZ . . .