Migration from Computer Modern Fonts to Times Fonts

R.E. YOUNGEN, W.B. WOOLF, AND D.C. LATTERNER

American Mathematical Society
201 Charles St.
Providence, RI 02904
rey@math.ams.com

Mathematical Reviews
P.O. Box 8604
Ann Arbor, MI 48107-8604
wbw@math.ams.com
dcl@math.ams.com

ABSTRACT

After several years of publishing in TℇX and (Almost-)Computer Modern, the American Mathematical Society has switched to TℇX and the Autologic Times family of fonts. This paper discusses the steps taken by the AMS to access Autologic's proprietary typefaces through TℇX and some of the difficulties encountered, particularly the problems associated with spacing in the math italic font. Although the procedures described are specific to the Autologic fonts, the principles outlined are applicable to other non-METAFONT fonts on other typesetters or printers.

1. Introduction and Background

In the early 1980s, the American Mathematical Society (AMS) and Mathematical Reviews (MR) (a division of the AMS which produces the secondary journal *Mathematical Reviews*[1]) were using a proprietary computer-driven typesetting system called STI (from Science Typographers Inc.) to typeset their publications, utilizing the Times fonts available on STI's Harris Fototronic typesetters. Around 1983, the AMS began using TℇX and the Almost-Computer Modern (AM) typeface for a small portion of regular journal production. For several years papers typeset with TℇX in AM fonts and those typeset with STI were incorporated into the same journals. This was true of the MR journal and *Current Mathematical Publications* (CMP) — MR's early awareness journal — as well: several of the indexes to these publications were set in TℇX while the main body was set in STI.

From 1983 to 1987, the percentage of papers typeset in TℇX at the AMS gradually increased, to the point that by mid-1987, STI had been completely phased out and 100% of the AMS's books and journals were being typeset in TℇX. Starting with the January 1985 issue of MR and Vol. 17, no. 1 of CMP, MR switched to TℇX exclusively. A history of MR and the reasons for that switch to TℇX (including the resulting efficiencies in multiple output formats from the common database and in user control of the journal design) are described in another paper presented to this conference.[2]

Although the AMS was a strong supporter of the TℇX project from its inception, a major drawback in using TℇX in production was the severe limitation on choice of typeface (only AM, and later CM, were available). There remained in the minds of several managers of MR and the AMS the concern that the AM fonts did not provide quite the right match of aesthetic qualities with efficient space utilization.

---

[1] A secondary journal carries abstracts and/or reviews (with bibliographic information) of articles published in primary journals and collections, as well as of monographs.

[2] "TℇX at *Mathematical Reviews*" by Latterner and Woolf.

This concern (coupled perhaps with a bit of nostalgia) became the impetus for the eventual return to publishing in Times.

2. The Switch Back to Times

When the AMS purchased an Autologic APS-μ5 typesetting machine in the spring of 1987, the entire family of Autologic Times fonts was acquired. Negotiations with Autologic led to an agreement allowing the AMS to obtain character widths for the Autologic fonts, as well as raster versions of the fonts, from which low-resolution fonts could be created.[3] Using the character width information, tfm files could be created for use with TeX, and the low-resolution versions of the Autologic fonts could be converted to a standard METAFONT output format (pxl format) for use on the laser proofing devices in the AMS headquarters office in Providence, Rhode Island, and the MR office in Ann Arbor, Michigan.

Coincidentally, MR was reviewing the typographic design of the MR journal, with Richard F. Southall serving as a consultant. Fortunately, Southall was at home in both the TeX/METAFONT environment and in the typographic considerations implicit in adapting the Autologic Times family to being driven by TeX. The team assembled for the conversion was led by Southall; major contributions were made by Ron Whitney of the AMS Providence staff, Dan Latterner of the Ann Arbor (MR) office, and (later) by Ralph Youngen of the Providence staff.

3. Creation of Times Text Fonts

A number of problems had to be overcome in order to create Autologic Times fonts for use with TeX: (1) Autologic fonts did not contain all the characters found in their Computer Modern counterparts; (2) characters within an Autologic font were ordered differently than TeX fonts; (3) the Autologic fonts needed to be "tuned" for use with TeX (i.e., kerning information had to be provided to TeX).

To overcome these problems, a utility called APStoPXL, written by ArborText of Ann Arbor, Michigan was used. APStoPXL allows for the creation of "composite" or "virtual" fonts, which are fonts that are composed of characters from several different fonts. This composite font scheme solved each of the problems listed above by: (1) allowing characters to be imported from other Autologic fonts or Computer Modern fonts; (2) providing a method to establish the correct correspondence between Autologic character positions and TeX character positions; and (3) providing a mechanism for kerning the Autologic fonts when used with TeX.

APStoPXL calls for the creation of a map file for each composite font. Each line in the map file contains information for a single character in the composite font. If a character is to be imported from another font, the name of the pxl file containing that character is given. The composite fonts created at the AMS were primarily composed of characters from one of the Autologic Times fonts, but characters were also imported from other fonts (Autologic and Computer Modern) to fill in the gaps. Autologic Times Roman, for example, does not contain the uppercase Greek characters found in cmr10, so these had to be imported from the Autologic Times Greek. Other characters, such as some of the accents and the dotless j, were brought in from cmr10. Ordering of the characters in the font was accomplished simply by listing in the map file the Autologic or imported characters in the order expected by TeX. Fine-tuning the inter-character spacing for the Autologic Times fonts required major efforts. The procedure used was essentially an iterative one in which the left and right sidebearings (the amount of space to the left and right edges of the "bounding box" for a character) were increased a small amount at a time and tested with all character combinations until suitable values were found. Although this process was somewhat automated, it was nonetheless time-consuming, since every combination of characters had to be viewed by human eyes.

APStoPXL takes as input the map file for the font and an Autologic Edscan-format file (which contains raster images of the Autologic fonts) and produces a standard METAFONT pxl file, as well as a pl file and an xpl file. The pxl file can be converted to a gf or pk format file for use with a standard laser proofing device. The pl (Property List) file can be run through the standard TeX utility PLtoTF to produce a tfm file. Finally, the xpl file (eXtended Property List) is run through another ArborText

---

[3] Unfortunately, to the best of our knowledge, the AMS is the only site that has been able to obtain raster versions of Autologic fonts.

utility called PLFONT to produce an amf file (Autologic Metrics File). The amf file is similar to a tfm file except that it contains device-specific information for every character in the font. This amf file is read by the device driver, DVIAPS; its purpose is to assign TeX character calls in the dvi file to the correct font and character position on the Autologic typesetter. Figure 1 illustrates this entire procedure.

The key to this system lies in the differences between the pl file and the xpl file. A character entry in the xpl file may contain any of the following device-specific parameters which control exactly how that character is to be typeset:

Parameter	Meaning
DEVWD	Specifies the width of the character.
DEVXOFFSET	Adjusts the horizontal placement of the character.
DEVYOFFSET	Adjusts the vertical placement of the character.
DEVFONT	Specifies the font in which the character is to be found.
DEVCHAR	Specifies the character position in the DEVFONT.
DEVXMAG	Specifies the amount to magnify the character horizontally.
DEVYMAG	Specifies the amount to magnify the character vertically.

The following excerpts from the pl file and the xpl file for the AMS's Autologic Times Math Italic font show the addition of device-specific information to the xpl file:

```
(CHARACTER O 17
   (CHARWD R 0.46273)
   (CHARHT R 0.495769)
   (CHARDP R 0.021397)
   (CHARIC R 0.075)
   (COMMENT
      (KRN O 177 R 0.055555)
      )
   )
(CHARACTER O 20
   (CHARWD R 0.5)
   (CHARHT R 0.745255)
   (CHARDP R 0.18)
   (CHARIC R 0.055)
   (COMMENT
      (KRN O 177 R 0.083333)
      )
   )
```

<div style="text-align:center">pl sample</div>

```
(CHARACTER O 17
   (CHARWD R 0.4627304)
   (CHARHT R 0.4957685)
   (CHARDP R 0.0213966)
   (CHARIC R 0.0749998)
   (COMMENT
      (KRN O 177 R 0.0555553)
      )
   (DEVFONT D 28801)
   (DEVCHAR D 16)
   (DEVWD R 0.4674005)
   (DEVXMAG R 1.1400003)
   (DEVYMAG R 1.1400003)
   )
(CHARACTER O 20
   (CHARWD R 0.5)
   (CHARHT R 0.7452554)
   (CHARDP R 0.1800003)
   (CHARIC R 0.0550003)
   (COMMENT
      (KRN O 177 R 0.0833330)
      )
   (DEVFONT D 14201)
   (DEVCHAR D 32)
   (DEVWD R 0.5100002)
   (DEVXOFFSET R -0.0100002)
   )
```

<div style="text-align:center">xpl sample</div>

METAFONT font designers have the ability to adjust the placement of each character within the tfm boundary. When typesetting with a manufacturer's native fonts, however, the placement of the character within its bounding box is not normally adjustable. However, using the parameters described above it is possible to attain complete control over how characters are to be typeset in relation to one another.
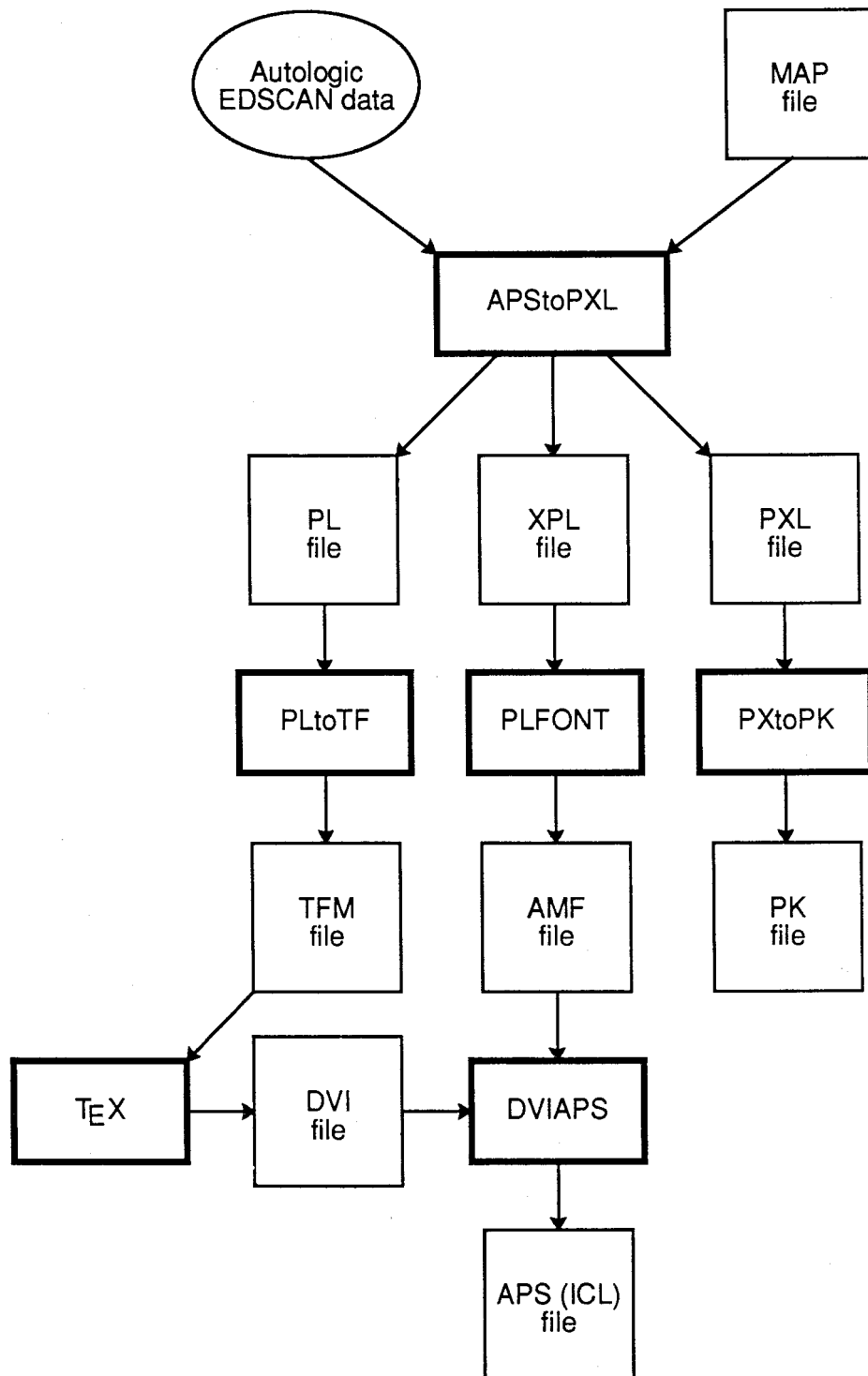
Figure 1: Overview of creation of Autologic fonts for use with TeX

4. Creation of a Times Math Italic Font

The AMS and MR had two options for a math italic font to use with the Autologic Times text fonts: simply use the Computer Modern math italic (cmmi10) or create a new Times math italic. Because of the significant differences in the style and weights of CM and Autologic Times, as well as the fact that Times had a greater x-height than CM, the creation of a Times math italic font was essential. At the same time, however, the difficulties of creating a math italic font were clear. The proper tests to run and parameters to change in the process of creating a math italic font were not as straightforward as they were for the creation of the text fonts, since TeX follows a different set of rules in math mode than it does in text mode. Italic correction, in particular, plays a very different role in a math italic font, since italic correction is added between adjacent characters from a math italic font.[4] In addition, the interaction of a math italic font with characters from the variety of different fonts that TeX processes in math mode (such as symbol, extension, and roman) has to be taken into account.

4.1 Spacing of Adjacent Math Italic Characters

To illustrate the difficulties involved, suppose that the spacing of the math italic character combination xy needs to be increased. There are four different ways that this could be accomplished: (1) increase the right sidebearing on the x, (2) increase the left sidebearing on the y, (3) insert a kern into the ligtable for the xy pair, or (4) increase the italic correction on the x. Note that all but option (4) would also apply for normal text fonts.

To determine which of these options to use, it is necessary first to decide whether the space should be added to the x or the y on a global basis, or whether this particular character combination is a special case that should be handled with a kern. For example, if other character combinations with the x also look too close, then space should probably be added to the right of the x. However, either option (1) or option (4) above would accomplish this in a math italic font.

To choose between these two options, it is necessary to look at how superscripts interact with the x character. This is because italic correction is added before a superscript is placed on a math italic character in math mode. If superscript placement on the whole looks good with x, then option (1) — increasing the right sidebearing on the x — ought to be done. If, however, superscripts are also too tight, then using option (4) — increasing the italic correction on the x — would solve both problems.

4.2 Spacing between a Math Italic Character and a Character from Another Font

Aside from math italic, TeX frequently uses characters from the symbol fonts and the math extension fonts when constructing math formulas. When the AMS and MR decided to create a Times math italic font, it was also decided that the symbol font cmsy and the math extension font cmex would be used in conjunction with the Times math italic. While the difference in x-height and weight between the Computer Modern characters from these two fonts and those of the Autologic Times fonts was still apparent, it was not considered to be as much a problem, since the symbol and extension characters are already quite different from text characters. In practical terms, there was actually no other choice: Autologic did not provide a set of math characters that covered the range of mathematical characters required to typeset mathematics. The decision to use cmsy and cmex, however, meant that if spacing problems arose between a Times math italic character and a character from one of these fonts, the Times math italic character had to be changed, and not the cm character.

Since kerns cannot be used between characters of different fonts, this means that the only options available are to change either the right sidebearing or the italic correction of the math italic character.[5]

Figure 2 shows a comparison of mathematics typeset using all Computer Modern fonts, versus mathematics typeset with the Computer Modern symbol and extension fonts and Times math italic.

---

[4] Note that if a kern is also specified between two characters in a math italic font, then both the kern and the italic correction are added between adjacent characters.

[5] Italic correction will still work since it is also applied when TeX switches from math italic to another font.

$$x \times y \qquad A \subseteq B \qquad t \to \infty$$

$$\int_0^\infty \frac{t - ib}{t^2 + b^2} e^{iat}\,dt = e^{ab}E_1(ab), \quad a, b > 0.$$

$$\pi(n) = \sum_{m=2}^n \left\lfloor \left(\sum_{k=1}^{m-1} \lfloor (m/k)/\lceil m/k \rceil \rfloor \right)^{-1} \right\rfloor$$

Figure 2a: Math output with CM fonts

$$x \times y \qquad A \subseteq B \qquad t \to \infty$$

$$\int_0^\infty \frac{t - ib}{t^2 + b^2} e^{iat}\,dt = e^{ab}E_1(ab), \quad a, b > 0.$$

$$\pi(n) = \sum_{m=2}^n \left\lfloor \left(\sum_{k=1}^{m-1} \lfloor (m/k)/\lceil m/k \rceil \rfloor \right)^{-1} \right\rfloor$$

Figure 2b: Math output with Times fonts

4.3 Other considerations

The inherent problem in adjusting the spacing of a math italic font is that there is an order of magnitude of difference between the number of visual spacings to adjust and the number of parameters available to make these adjustments. Every character can potentially be typeset against every other character either as adjacent characters, or with one or the other in the superscript or subscript position. This leads to a large number of possible character combinations with relatively few parameters to make the necessary adjustments.

As a result, changes to a single parameter cause visual changes to a great number of spacings, as in the case where adjusting the italic correction on the x to obtain more spacing between the xy pair would also adjust the space between every character combination using x on the left and all superscripts typeset on the x. Therefore, a constant game of compromise must be employed when adjusting any of the parameters.

The tendency may be to use kerns too frequently to solve specific spacing problems. This approach is valid, except for the fact that each font in TeX can only have up to 255 LIG and KRN commands in the ligtable. Thus, careful decisions must be made to classify every spacing problem as either a "global" problem with a single character, or a "specific" problem with a pair of characters.

5. Conclusion

While the difficulties of training TeX to set non-METAFONT fonts are great (though not insurmountable), the results are certainly worth the effort. Other Autologic fonts that were purchased by the AMS have since been made available to TeX, and the procedure is becoming easier with more experience. The appearance of many of the AMS books and journals and of MR is, in the opinion of many involved, greatly improved. The purely aesthetic question of which typeface is more attractive is too subjective for quantitative evaluation, and, in the case of the MR journal, separating the contribution of macro design changes from those of changes in typeface is difficult. The reader is invited to make her/his own choices: Figure 3 displays the same MR review set in Almost-Computer Modern using the old design format and in Autologic Times using the new design format.

6. Update

During the TUG conference sometime after this paper had been presented, Prof. Knuth endorsed the use of the xpl/amf system, and challenged implementors of dvi drivers to utilize the design. David Rodgers, president of ArborText, also announced that he would make the specifications of the xpl and amf format available to the TeX community in a future issue of TUGboat.

60J Markov processes

Knuth, D. E. (1-STF-C)   86c:60112
  An algorithm for Brownian zeroes. (German summary)
  Computing **33** (1984), *no.* 1, 89–94.
  Let $B(t)$ be the Brownian motion on $[0,1]$ starting at $a \neq 0$, and $B^{(n)}(t)$ its polygonal approximation, formed by setting $B^{(n)}(t) = B(t)$ for $t = i/2^n$, $i = 0, 1, \cdots, 2^n$, and interpolating linearly elsewhere. This paper is concerned with an efficient algorithm for simulating the number and positions of the zero crossings of $B(n)$, without necessarily simulating $B^{(n)}$ itself. Briefly, the idea is as follows: divide $[0, 1]$ into two equal parts, and "decide", with the appropriate hitting probability, whether B might have a zero crossing in either. An empty interval is ignored. If there is a zero crossing, divide that interval into two equal parts, and proceed as before, until the required level of resolution is reached. Simulation of B at each interval end point that enters into this procedure is required. The algorithm requires $O(2^{n/2})$ simulations of Gaussian variates, as opposed to $O(2^n)$ required by the obvious direct method of first simulating all of $B^{(n)}$.   *Robert J. Adler* (Haifa)

Figure 3a: Sample review from *Mathematical Reviews* set in Almost Computer Modern

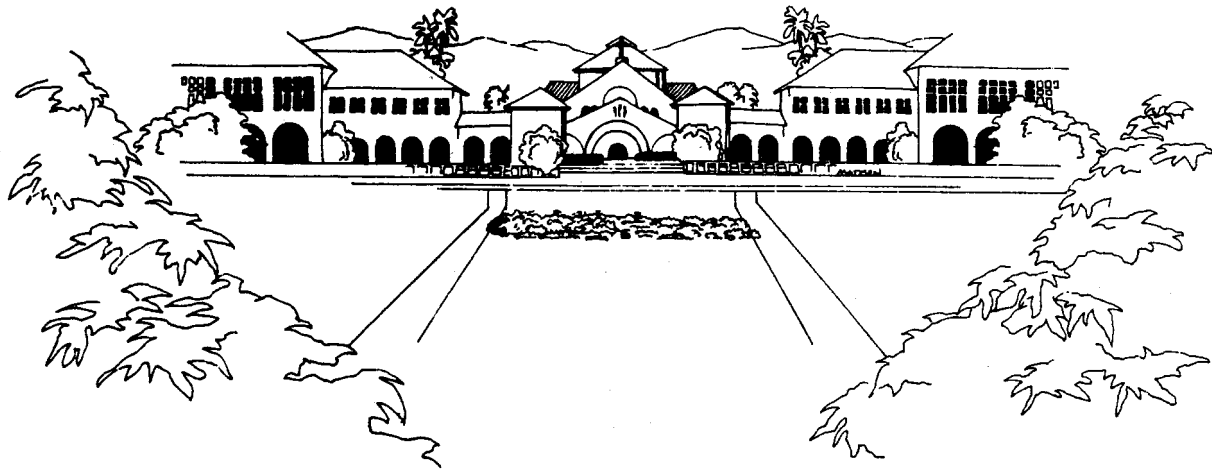## 60J Markov processes

86c:60112 60J65 65C10
Knuth, D. E. (1-STC-C)
An algorithm for Brownian zeroes. (German summary)
Computing **33** (1984), *no.* 1, 89–94.
Let $B(t)$ be the Brownian motion on $[0, 1]$ starting at $a \neq 0$, and $B^{(n)}(t)$ its polygonal approximation, formed by setting $B^{(n)}(t) = B(t)$ for $t = i/2^n$, $i = 0, 1, \cdots, 2^n$, and interpolating linearly elsewhere. This paper is concerned with an efficient algorithm for simulating the number and positions of the zero crossings of $B(n)$, without necessarily simulating $B^{(n)}$ itself. Briefly, the idea is as follows: divide $[0, 1]$ into two equal parts, and "decide", with the appropriate hitting probability, whether B might have a zero crossing in either. An empty interval is ignored. If there is a zero crossing, divide that interval into two equal parts, and proceed as before, until the required level of resolution is reached. Simulation of B at each interval end point that enters into this procedure is required. The algorithm requires $O(2^{n/2})$ simulations of Gaussian variates, as opposed to $O(2^n)$ required by the obvious direct method of first simulating all of $B^{(n)}$.   *Robert J. Adler* (Haifa)

Figure 3b: Sample review from *Mathematical Reviews* set in Autologic Times

TeX Users Group

Stanford University, August 11–14, 1985
Terman Engineering Center Auditorium