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Born Broken: Fonts and Information Loss in Legacy Digital Documents

Geoffrey Brown & Kam Woods

School of Informatics and Computing

Indiana University Bloomington

Abstract

For millions of legacy documents, correct rendering depends upon resources such as fonts that are not generally embedded within the document structure. Yet there is a significant risk of information loss due to missing or incorrectly substituted fonts. Large document collections depend on thousands of unique fonts not available on a common desktop workstation, which typically has between 100 and 200 fonts. Silent substitution of fonts, performed by applications such as Microsoft Office, can yield poorly rendered documents. In this paper we use a collection of 230,000 Word documents to assess the difficulty of matching font requirements with a database of fonts. We describe the identifying information contained in common font formats, font requirements stored in Word documents, the API provided by Windows to support font requests by applications, the documented substitution algorithms used by Windows when requested fonts are not available, and the ways in which support software might be used to control font substitution in a preservation environment.[1]

[1] This paper is based on the paper given by the authors at the 6th International Conference on Preservation of Digital Objects (iPres 2009), October 2009; received January 2010, published March 2011.

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Overview

Q: I need "font x". ... Can you tell me where I can get it?

A: This is very unlikely, as there are over 100,000 digital fonts in existence.[2]

Doubtless, many readers have witnessed PowerPoint presentations where the slides were clearly missing *glyphs* (visible characters) or were otherwise poorly rendered. In most cases, this unhappy event is the direct result of copying the presentation from the machine upon which it was created to a machine provided for the presentation without ensuring that the target machine has the required fonts. This reason is not always clear to the presenter because Microsoft Office performs font substitution without warning.

Annoying font substitutions occur frequently. For example, symbols such as apostrophes and quotations are rendered with the "WP TypographicSymbol" font in WordPerfect Office 11. When these documents are migrated to Microsoft Word, this font dependence is preserved, and when the documents are rendered on machines without this font, these symbols become "A" and "@" as in: "in the AStrategies and Assessment@Column".[3]

The degree of information loss due to substitution depends both upon the importance of the glyphs substituted and their frequency. For example, corporate logos are often implemented with dedicated fonts containing a single glyph. There may be no substantive information loss from a missing logo for most purposes. In contrast, substitution for mathematical symbols may result in total information loss. For example, our experimental data include nine documents with program listings for the Texas Instruments TI-83 series calculators rendered with the `Ti83Pluspc` font, which provides various mathematical symbols; these program listings are incomprehensible when rendered without this obscure font. This is illustrated in Figure 1. Compounding the problem, Texas Instruments has published a variety of calculator fonts with different internal names and possibly incompatible glyphs.

```
Lbl A:ClrHome
If N<4:Goto Ø
CubicReg L₁,L₂:3→T:"aX³+bX²+cX+d"→Y₁
Disp "aX³+bX²+cX+d"
```
Correctly Rendered

```
Lbl A:ClrHome
If N<4:Goto 0
CubicReg L ,L,:3üT:"aXÓ+bXÜ+cX+d"üY
Disp "aXÓ+bXÜ+cX+d"
```
Default Substitution

Figure 1. TI83plus Font Samples.

In the process of preparing this paper we found several documents with

[2] Microsoft Typography: http://www.microsoft.com/typography/FontSearchFAQ.mspx.
[3] WordPerfect Universe: http://www.wpuniverse.com/vb/showthread.php?threadid=16756.

barcodes rendered using the font "Barcode 3 of 9 by request". When rendered with font substitutions, the bar codes of the numbers are replaced by Arabic numerals. Thus, the substitution preserved the numeric meaning, but not the functional ability to be scanned! Unfortunately, there are many barcode fonts and we were unable to find the required font; however, we were able to find a suitable substitute and to configure Office to accept our substitute as illustrated in Figure 2.

0260931

Default Substitution

Forced Substitution of "Code39Azalea"

Figure 2. Barcode Rendering.

It is difficult to create portable documents that will not suffer from font substitution when moved to another machine. Fonts are installed on a platform by the operating system, by applications, and by individuals. A user has no way to distinguish between standard fonts offered in an Office menu and those that have been installed by other applications. For example, ESRI provides fonts with its various GIS applications. While these are relatively specialized applications that are unlikely to be present on most platforms, there is nothing preventing an Office user from utilizing the associated fonts. Furthermore, even the set of standard fonts changes over time – the fonts installed by Windows XP are not identical to those installed by Vista. Because of significant differences in the machine environments, there is a high probability that transferring a document between machines will result in missing fonts.

A solution to the problem of missing fonts for document preservation requires three components: identification of missing fonts, acquisition of the fonts or suitable substitutes, and configuring a suitable rendering environment including all fonts or their substitutes. In this paper we focus on the problem of font identification. The issues we discuss include extraction of font identification data from digital documents, the use of that information to match against a database of known font identifiers, and techniques for controlling font substitution.

The central analysis in this paper is based upon two large collections of Word documents – one described by Reichherzer and Brown (2006) and gathered using glossary queries to Google; the second exclusively gathered from ".gov" sites. The second collection was created to test an hypothesis that government documents might use more restricted font sets; however, that did not prove to be the case.

To test our ability to match font requirements with font names we gathered font name information from several major vendors and application software. Names were extracted from fonts, from published lists of fonts and from tables of names provided by vendors.

While the results initially appear depressing – a common desktop environment can correctly render around 75% of a document collection – there are indications that with modest work the fonts required to faithfully render 92% of a collection can be readily identified. The problem of identification is unsolvable in an absolute sense, as in any collection of documents there are likely to be required fonts that cannot be reasonably identified. There are simply too many fonts which have been in use and the data on font names available from font foundries or the fonts themselves too sparse to guarantee identification. Furthermore, some documents may include fonts with corrupt name information – we have seen examples of documents with indecipherable font names.

The remainder of this paper is organized as follows. We begin with a discussion of font formats (e.g., TrueType) and the available font identification information. By gathering information from fonts and font vendors, we have created a database containing several thousand popular fonts. We then describe the information available in Office documents and our use of open source libraries to extract the names of fonts referenced by these documents. Finally, we describe experiments to match font names extracted from Microsoft Office documents with names in our database.

Background

Fonts

A font consists of a set of glyphs indexed by *codepoints* (integers) within one or more *codepages* (a defined codepoint to a character mapping, such as the Latin alphabet) along with various geometric rendering information. Two fonts may be suitable substitutes if they contain similar glyphs for all codepoints. While this is frequently the case where the glyphs represent characters from common alphabets, there are many special case of symbolic characters (e.g., mathematical, scientific, or icons) where substitution of glyphs from another font destroys the underlying meaning of the document.

While there have been many font formats in use, the two most common formats for Windows platforms are PostScript and TrueType. There are still bitmapped fonts distributed with Windows for MS-DOS compatibility (FON files) which do appear to be used in some Office files. However, other than noting that they contain name strings that can be extracted, we do not discuss them further.

Although PostScript fonts appear to be in the decline, they were the dominant font format for at least a decade. There are several PostScript font formats (e.g., types 0, 1, and 2) but many of the differences relate to how glyphs are defined. For font identification, the key information provided in every PostScript font includes ASCII strings identifying the font version, family name, font name, and full name (Adobe Developer Connection, 2009). The full name shows the complete name of a typeface including style and character set information, and is typically used in font menus. The font name generally contains much of the same information as the full name, but in a compressed form limited to 29 characters. There are conventions for this compression (for example, a rule that reduces the “words” to a string with 5, 3 and 3 characters); however, it can be challenging to relate the font name strings with published lists of fonts (Microsoft, 2009a).

TrueType was developed by Apple as a competitor to PostScript fonts and was subsequently adopted by Windows. Today, TrueType is the most common font format for Mac OS, the X Windows platform and Microsoft Windows. The file format for TrueType is now covered by the OpenType specification (which can serve as a container for PostScript fonts). OpenType files are organized as a set of tables. The most important tables for our work are the naming tables (*name*) and the table (*OS/2*) containing Windows metrics, including the Unicode and Windows code page ranges. The name table includes various strings keyed by platform, encoding, language and name. Platforms include Windows and Macintosh. Encodings are platform-specific – on the Macintosh these correspond to script manager codes (e.g., Roman, Japanese, etc.), whilst on Windows, common encodings include Unicode UCS-2 and UCS-4.

OpenType language IDs are platform-specific and are used to indicate various language-specific translations of the name strings. The types of names include copyright, font family, font subfamily, full font name and PostScript names. The language used in font name strings within Office documents corresponds (where available) to the language for the Windows platform upon which the document was created; for example, “Arial Bold”, “Arial Negrita”, “Arial Vet”, and “Arial Gras” are the English, Spanish, Dutch, and French names for the same font. In gathering font data for this paper we found that only the most widely used fonts tend to have name strings in multiple languages and several large foundries provided only English names strings with the majority of their fonts.

Fonts in Windows and Word

In this paper we concentrate on the legacy Microsoft Word binary format. While we have performed no specific work with other formats (e.g., WordPerfect) there is good reason to believe that the conclusions will be similar because application programs, such as Word and WordPerfect, depend upon the underlying operating system API for access to and rendering of installed fonts. The font information embedded in a document is ultimately based upon the information available from the system API. Thus, we begin with a brief examination of the Win32 font functionality as described in the MSDN documentation (Microsoft Developer Network, 2009). A complete analysis examining the APIs of other operating systems (e.g., for the Macintosh) is beyond the scope of this paper.

The central data structure used by an application to exchange font information with the Windows operating system is the “logical font” or LOGFONT structure that is used to describe the most significant features of a font. Applications create LOGFONT structures to request that Windows find a matching font and Windows enumerates available fonts for applications by generating LOGFONT structures. The structure provides information such as weight, orientation and style (e.g., script, decorative, Roman), as well as a (maximum) 32-character (Unicode or ASCII) name for the font. The metrics provide geometric information such as pitch and width, style information such as italic or underlined, and information about the range and type of the character set supported (e.g., ANSI, Symbol, Turkish). The type information can be used to distinguish “Raster fonts”, “Vector fonts”, “TrueType fonts”, and “Downloadable fonts”.

Word documents store their knowledge about fonts in a similar structure table of "font family names" (FFN), which include the name string (from the LOGFONT structure), a flag indicating whether the font is TrueType, the character set, the font weight and style, PANOSE number, and a 20-byte "font signature" (Microsoft, 2009c). The name string is either in UTF-16 or ASCII depending upon the version of Word creating a document. The font signature indicates the Unicode (16 bytes) and Windows code pages (8 bytes) for which the font contains glyphs. Similar data exist in the OS/2 metrics table for OpenType fonts and *might* be useful for verifying that a font file matches the font referenced by a Word document.

PANOSE numbers were developed in the 1980's (Bauermeister, 1987) as a mechanism for classifying fonts with the explicit goal of identifying good substitutes. While TrueType fonts include PANOSE numbers, and Word retains those numbers in its font tables, published research suggests that PANOSE has not been widely implemented correctly, with many fonts having "default" values (Impson, 2005).[4] Furthermore, where PANOSE is used correctly the information is likely to be of little added value for font identification because these fonts tend to be those distributed by major vendors such as Microsoft, for which accurate font name data has been recorded.

In our work, we rely upon the font name strings extracted from Office documents. While every Word document contains a single font name table, not all fonts listed in this table are used by the document. Furthermore, our experience suggests that as a document evolves, Word fails to properly delete unused entries and empty or "garbage collect" name strings. Thus, extracting the set of valid name strings requires walking the document character by character.

Font Matching Experiments

In this section we use two data sets totaling approximately 230,000 Word documents to evaluate the difficulty of identifying referenced fonts, given a database of font information. The primary identification technique we utilize is based upon name matching; however, we also evaluate the utility of the other font metrics recorded in Word documents.

We had hoped to build a database of font information extracted from the fonts published by the major foundries; however, we found most foundries reluctant to provide the requested information and the cost of purchasing fonts was not justified by this exploratory research.[5] We resorted to combining information from a variety of sources, including font files and font name information provided by several major foundries, extracted from published lists, and retrieved from foundry web pages. The font collections include fonts provided with various Mac OS X and MS Windows distributions, fonts distributed with applications such as Microsoft Office and WordPerfect, and fonts donated by Bitstream. The font data we collected are summarized in Table 1.

[4] High-Logic Font Forum: http://forum.high-logic.com/viewtopic.php?f=13\&t=2600.

[5] We are grateful to Bitstream for providing a large collection of fonts, and to FontFont and URW for providing tables of font name information.

To determine the fonts used in Word documents we wrote a custom application based upon the open source library `libwv`, which is the basis for file import in Abiword and other applications (Lachowicz, 2009). Through comparing key aspects of `libwv` with the published specification, we believe that it is relatively correct. There are aspects of the specification that are far from clear, and specific notes point to items requiring further work. The `libwv` software provides a basic document processing function with application-specific callback functions. For our work, it was necessary only to provide a function to track the fonts specified at the beginning of a text run and a function to process each character in a text run. For each font in the document name table, we record both the codepoints used and the number of characters referencing the font. Selection of the correct font for a given character is actually done incorrectly in `libwv`, as the code does not implement the "font calculation" described in Appendix B of the Word 2007 Binary File Format document (Microsoft, 2009c). We corrected this error in our work. Our code generates reports including the active font names with the number of codepoints and characters from each font, as well as the other font metrics recorded in the Word document.

Source	Data Type	Number of Fonts
Foundry		
Adobe	Published Table	2374
Bitstream	TrueType Fonts	1556
FontFont	Foundry Supplied Table	11973
URW	Foundry Supplied Table	2358
Operating System		
Microsoft Windows + Office	Font Files	444
Mac OS X + Office	Font Files	322
Application		
Adobe PostScript	Published List	103
Microsoft Applications	Published List	537
WordPerfect	TrueType Fonts	1080

Table 1. Font Data.

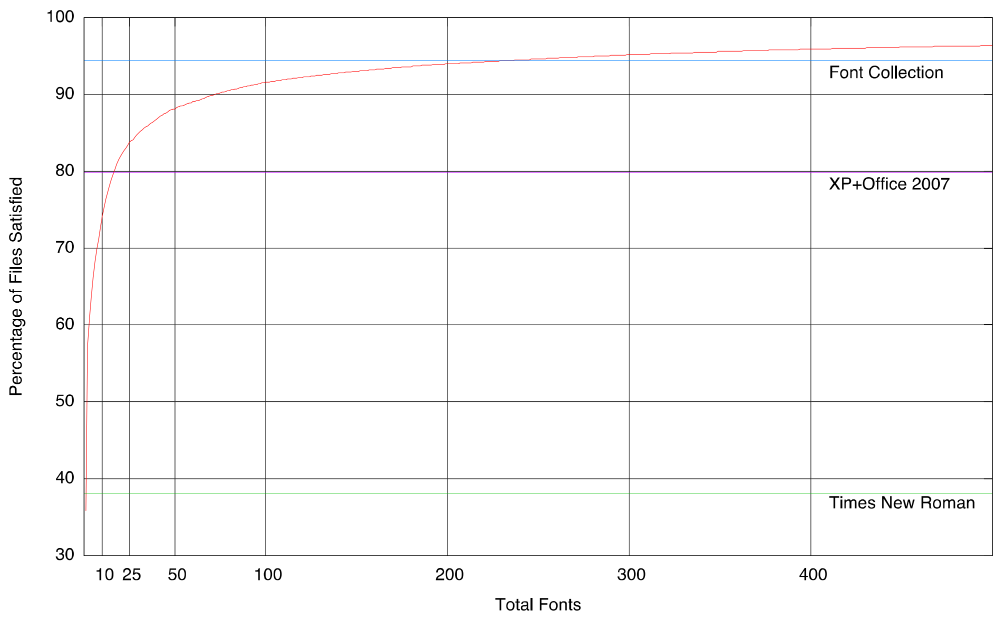


Figure 3. Font Usage for Glossary Documents.

Given the font information extracted from a collection of Word documents and a database of font names we can determine which extracted names *exactly* match names in the database. While there appear to be opportunities to apply various heuristics for inexact matching (for example, longest matching prefixes), our examination of the names suggests there are many special cases, thus we studied exact matching as a baseline. We matched names against three distinct name sets: our complete collection, the names extracted from an installation of Windows XP and Office 2007, and the single name "Times New Roman", which is the most common font referenced in our data sets.

Our metric for each font collection is the percentage of documents whose font requirements can be completely met (satisfied) by that collection. We compare these results with the percentage of "satisfied documents" given font collections of the *N* most referenced fonts for all values of *N*. The results for our glossary based collection (3910 fonts) are illustrated in Figure 3 and those for the ".gov" documents (1920 fonts) are illustrated in Figure 4. Although the total number of referenced fonts differs, the overall results are quite similar: roughly 31-39% satisfied by Times New Roman, 72-79% satisfied by XP and Office, and 90-94% satisfied by our more comprehensive collection. Notice that in both cases the top 100 fonts satisfy approximately 92% of the documents.

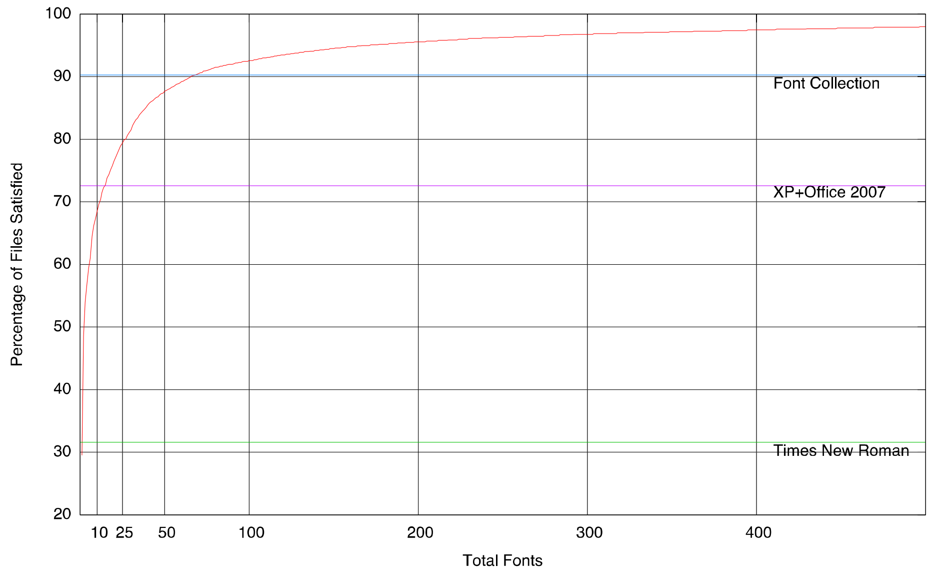


Figure 4. Font Usage for Government Documents.

As mentioned above, exact name matching is probably too pessimistic. For example, we noticed many variations on fonts including the word "Times". Some of this variation is due to similar fonts published by different vendors, some is due to changes in name conventions from the early bitmapped fonts to PostScript fonts to Truetype, and some is due to significant differences. The top 10 "Times" fonts and their fraction of reference from the two document collections is illustrated in Table 2. The complete list comprises 375 fonts and 49% of all font references. Note that the values in Table 2 are calculated from the *total number of references* rather than the percentage of documents satisfied.

Even if all variations on “Times”, after suitable analysis, proved to be equivalent, the overall problem isn’t significantly simplified. The extremely long tail on font usage means achieving a 95% satisfaction level for a document collection is tractable, achieving 99% may not be feasible. Furthermore, our experience suggests that finding many of the identified fonts will be quite challenging.

Times New Roman	42.00%
Times	3%
CG Times	1%
TimesNewRoman	0.5%
Times New Roman Bold	<0.5%
TimesNewRoman,Bold	<0.5%
Times New (W1)	<0.5%
CG Times (W1)	<0.5%
TimesNewRomanPSMT	<0.5%
Times-Roman	<0.5%
…	...
Total (375)	49.00%

Table 2. Times Variations. Percentages calculated from number of times each font variation is encountered.

Ultimately, preservation of documents will require selection of suitable font substitutes either because a particular font cannot be obtained or cannot be identified. Thus, we examined other data that might aid in characterizing suitable substitutes or in determining whether a required font is critical to preserving the information content of a document.

The primary additional font metrics available from Word documents include the font family (Roman, Swiss, etc.) and pitch, the font weight, PANOSE number, and Code sets (Unicode and Windows). The two font families that are likely to be safely substituted are Roman and Swiss (serif and san serif fonts respectively). It is less clear whether Modern or Script can be substituted, and Decorative generally cannot be substituted. As illustrated in Table 3 and Table 4, either the font family or pitch information has a “default” value for nearly 40% of all referenced fonts. The font family categories are described by Microsoft (2009b).

Default	40%
Fixed Pitch	3%
Variable Pitch	57%

Table 3. Font Pitch.

Default	Do not care or don’t know	42%
Roman	Serif fonts with variable stroke width	28%
Swiss	San serif fonts with variable stroke width	21.5%
Modern	Constant stroke width	4.5%
Script	Handwriting	2%
Decorative	Novelty and other	2%

Table 4. Font Family.

Unicode range and Codepage information can be used to analyze font data at a finer granularity, providing a clearer picture of why a particular font may be used in a given document (e.g., in order to satisfy the need for particular glyphs) and potential guidance on the selection of a suitable substitute. We intend to explore the use of such information in future research.

As mentioned, many fonts are used for a single or few glyphs. In the case of the document collections studied, nearly 10% of all referenced fonts were used for only a single glyph. Unfortunately, even assuming all these fonts are known (by adding the names to our database) doesn't appreciably alter our "satisfaction" rate.

Font Substitution

Locating missing fonts using name strings as a primary identifier is challenging. While a number of websites provide a font search (one-at-a-time) based upon large databases, they are often incomplete, inaccurate, and cannot be automatically queried. We encountered a variety of problems with names containing non-ASCII characters, compressed names, variations of known names, and rare or specialized fonts. Processing compressed names in particular may be platform specific. For example, the Windows fonts named "Helv" and "Tms Rmn" in Windows 3.0 were renamed to "MS Sans Serif" and "MS Serif" respectively in Windows 3.1. Modern iterations of the Microsoft operating system maintain a system-accessible map in the font substitution registry subkey to correctly map these names. However, on Macintosh platforms the proper substitutions remain unavailable.

Font substitution in Microsoft Windows is performed according to a "closest match" criteria calculated as a weighted sum from a vector of information corresponding to the LOGFONT structure. As the name suggests, this information does not correspond to a "physical" font (e.g., the data that define a font installed or loaded into the task environment) but rather a "logical" font composed of a sequence of properties, requested as a result of a user action or application request during the loading of a document.

When an application is tasked with displaying text in a given font, it performs an API function call populated with values from the LOGFONT corresponding to the desired (logical) attributes. Windows realizes a best match to the desired font by searching the installed fonts to find one with values closest to this attribute set. As previously noted, these attributes include font family names, font weight, font width, and font slope. An obvious consequence of this is that the (absolute) best match may correspond to a font not installed on the system.

Font matching information is pre-calculated and cached from existing font collections according to a detailed algorithm designed to support efficient font matching on request. In addition to the attributes noted above, this process includes the generation of combined Family and Face names, extraction and resolution of various terms for style and weight (for example, "Bold Face" to be treated the same as "Bold"), and the extraction of canonical numerical representations.

Fonts are subsequently matched by location of an exact (or longest-substring match) FontFamily name, a matching face from the candidate face list (computed as a weighted attribute vector based on FontStretch, FontStyle, and FontWeight – prioritized in that order), and localization settings.

Microsoft provides detailed information on font matching in Windows under the Windows Presentation Foundation (Microsoft, 2006). In some cases, a matched font may not contain the required glyphs (for example, a font with a Latin-only glyph-set requested to render glyphs in an unsupported codepoint range). The Microsoft Unicode-rendering service, Uniscribe, will automatically render the unsupported script in the appropriate fallback font (Kaplan, 2009). In addition to this "transparent" glyph substitution, fonts (in Windows 2000 and later) may also be *linked*, providing the ability to explicitly select add codepoints to a "base font" for which additional glyphs are desired.

In order to provide more accurate mapping from logical to physical fonts and to account for improved rendering technologies, Microsoft introduced improved APIs in Windows XP (moving from GDI to GDI+) and Windows 7 (with the development of DirectWrite). As a result, the font substitution actions performed by different versions of Microsoft Office may be inconsistent. Additionally, the default font substitution algorithm implemented in GDI+ may be overridden within an application.

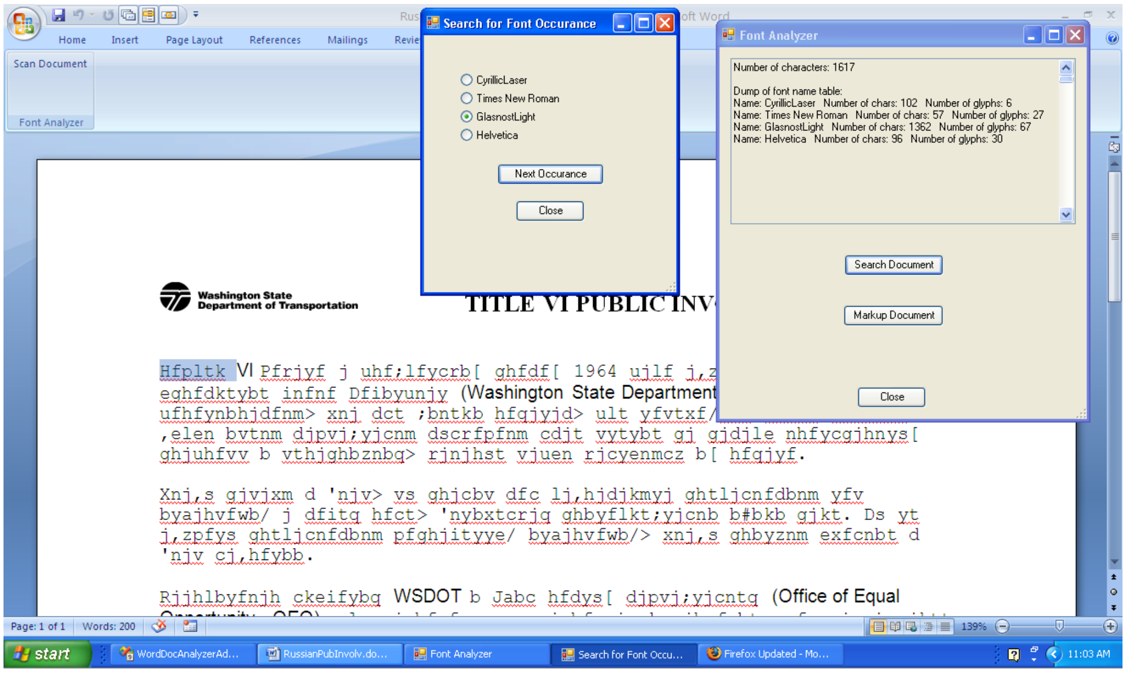
Because of this, it can be difficult to accurately replicate substitution actions performed by a proprietary application such as Microsoft Word. This can be demonstrated via a simple experiment using fonts provided with the operating system. If a LOGFONT structure is populated completely with information from a font loaded into the system font table using an API call such as `AddFontResourceEx()`, and that font is then unloaded, a subsequent call to the function `CreateFont()` under Windows XP (GDI+) will frequently result in mapping that differs from the substitution performed by Microsoft Office.

Exacerbating the problem, there is not enough information included in a legacy Word (.doc) file for any font used to completely fill the LOGFONT structure. Font information that *is* available, such as the PANOSE number or a substitution "hint", cannot be passed directly to font mapping functions within GDI+. This is important because it exposes a significant preservation issue; even when document specifications are well documented (or fully open), the behavior of the application most commonly used to render those documents becomes the de facto standard for all rendering services. If the behavior of such an application depends on code or API functions that are not generally exposed, the "openness" of the format is not necessarily a guarantee of preservation-friendliness.

David Levy notes that the severity of the risk posed by font substitution depends on a variety of factors, that "even in these simplest of cases, sensitivity to the circumstances of use is crucial to determining what is to be preserved – what counts as successful preservation" (Levy, 1998). Font selection algorithms are complex, and the substitution actions performed may be opaque to anyone who is not a typographer or software developer. However, simple tools can assist the user in determining the degree to which a rendered document is well-formed (or exhibits information loss).

Given that font substitution risk is inevitable, we developed a prototype tool to enable users of Word to easily locate the specific text where a particular font occurs and to enumerate the number of glyphs used. We extended the functionality of our `libwv`-based tool with a small custom plug-in written in C# for Microsoft Word. This tool preprocesses the document as described in the Font Matching Experiments section, and presents the user with a dialog identifying the total number of document characters, a dump of the font name table along with the total number of glyphs in the font actually used in the document, and buttons to mark up (highlight) or search the document for specific font occurrences *irrespective* of whether they have been correctly rendered or subject to substitution.

In the example illustrated in Figure 5, the unavailable Cyrillic font "Glasnost Light" has been substituted by a font which does not contain glyphs in the appropriate character range. This particular example uncovers another subtle problem with font identification. The publisher of the version of the Glasnost Light font used in this document had remapped an existing character range – in this case, standard Western ASCII characters for Cyrillic glyphs. We discovered this only after we had located what we believed to be the correct version of the font. The rendered document remained garbled (albeit this time with Cyrillic characters) due to the fact that we had selected a version of the font with the Cyrillic characters in the proper code page.



CyrillicLaser
Times New Roman
[✓ GlasnostLight]
Helvetica

```
Number of characters: 1617

Dump of font name table:
Name: CyrillicLaser   Number of chars: 102   Number of glyphs: 6
Name: Times New Roman   Number of chars: 57   Number of glyphs: 27
Name: GlasnostLight   Number of chars: 1362   Number of glyphs: 67
Name: Helvetica   Number of chars: 96   Number of glyphs: 30
```

TITLE VI PUBLIC INV

```
Hfpltk VI Pfrjyf j uhf;lfycrb[ ghfdf[ 1964 ujlf j,z
eghfdktybt infnf Dfibyunjy (Washington State Department
ufhfynbhjdfnm> xnj dct ;bntkb hfqjyjd> ult yfvtxf/
,elen bvtnm djpvj;yjcnm dscrfpfnm cdjt vytybt gj gjdjle nhfycgjhnys[
ghjuhfvv b vthjghbznbq> rjnjhst vjuen rjcyenmcz b[ hfqjyf.

Xnj,s gjvjxm d 'njv> vs ghjcbv dfc lj,hjdjkmyj ghtljcnfdbnm yfv
byajhvfwb/ j dfitq hfct> 'nybxtcrjq ghbyflkt;yjcnb b#bkb gjkt. Ds yt
j,zpfys ghtljcnfdbnm pfghjitynye/ byajhvfwb/> xnj,s ghbyznm exfcnbt d
'njv cj,hfybb.

Rjjhlbyfnjh ckeifybq WSDOT b Jabc hfdys[ djpvj;yjcntq (Office of Equal
```

Figure 5. Word Plug-in Identifying Substituted "Glasnost Light" Text.

We believe that these tools can be incorporated into risk assessment workflows in a manner that is both low cost and highly reliable. Batch processing using our previously described tool can be used to rapidly and automatically flag potential high-risk documents, which may then be presented to the user via the augmented Microsoft Word interface in order to determine the actual risk.

Discussion

We have shown that the majority (up to 79%) of digital documents obtained from a wide range of sources can be rendered accurately using fonts appearing in modern desktop environments such as the combination of Microsoft Windows and Microsoft Office. With a small amount of additional work – using information drawn from font foundries, or performing family name matches for legacy fonts or commercial fonts for which distribution has ceased – we can expect to increase this coverage to 92%.

This nevertheless leaves a large number of documents unaccounted for. Microsoft's own search engine indexes nearly 60 million documents currently available on the web. At this level of coverage, 1.8 million documents are guaranteed to be rendered inconsistently on a typical workstation. For many of these documents, the loss of information may be negligible. It is impossible, however, to quantify this without appropriate software tools to analyze the risk to a particular collection.

Even with access to the full documentation for a legacy proprietary format, replicating the behavior of the original environment used to render that document can be extremely difficult – or impossible – for tasks as seemingly basic as font selection and use. Publishers and institutional archives build support around work-flows optimized for "born archival" documents, the majority of the documents produced in the world today continue to be created using proprietary office software with font embedding disabled. While there has been significant uptake in the development and use of open syntactic specification for documents, the font identification and selection problem remains.

A significant barrier to improving document creation practices that facilitate future access is the simple fact that many software products do not embed fonts by default, but require additional action on the part of the user. Problematically, even enabling font embedding does not guarantee that the document will fully support all types of access. For example, at the time of writing, Microsoft Word 2007 and 2010 do not examine embedded OLE objects created with MS Equation 3.0 or MathType when directed to embed fonts, an issue compounded by the fact that the MT Extra font installed on the host system by MathType contains additional glyphs not present in the version distributed by Microsoft (Microsoft, 2010a). Although a domain expert viewing incoherently rendered equations in the future may have little trouble recognizing that there is a problem with the document, recreating the appropriate rendering environment remains difficult. Furthermore, TrueType fonts may be created with properties that restrict the degree to which they may be used on systems other than the originating host; certain fonts may be fully installed from an embedded context, installed temporarily, embedded read-only, or disallow embedding.

The use of formats such as archival PDF, which has been extensively discussed in preservation literature (Fanning, 2008), is in some ways orthogonal to the key problems identified here. Governments and private institutions rely on software such as Microsoft Word for ease of interchange, edit, and reuse, and will likely continue to do so for the foreseeable future. Additionally, many millions of legacy documents are currently available on the web in both legacy and modern office software formats – a backlog of significant historical data. Practices such as those described in this paper can help in identifying those documents that are likely to be "high risk" during otherwise automated ingest procedures.

Font handling is heavily contextual, relying on technical information drawn from the font itself, the document creation software and environment, and finally the rendering or document migration platform. Collating and analyzing this information to identify risk factors is difficult and time-consuming, since many features of both fonts and rendering environments either lack public documentation or are addressed only on technical forums available via disparate Internet sources. Companies that produce and license fonts are frequently reticent about releasing further documentation on their intellectual property, and even when the algorithms used to render documents in common office software applications are well-documented, analyzing and replicating their operation is frequently difficult.

Automated tools to simplify the identification and location of missing fonts in document sets can significantly reduce the risk of information loss in an archive. As part of our ongoing research, we are developing tools to assist archivists in processing and analyzing font information from large collections of documents. Our current tool is capable of automatically preprocessing collections of Microsoft Word documents, identifying ranges of characters for which fonts are not available, and rendering those ranges separately from the remainder of the document for examination. In concert with this tool, we have developed a plug-in for Word which automatically locates and highlights ranges for which fonts or characters have been substituted. Future iterations of the tool may be adapted to use unicode ranges for language identification, or incorporate existing language identification software to assist in separation of human language and symbolic font uses.

Our research demonstrates the need for simple, effective tools to correctly identify font information and locate missing font data in order to facilitate lossless rendering. We show that effective rendering of heterogeneous document collections can only occur when supported by a database of information drawn from multiple vendors; no existing identification technology provides universal or even adequate coverage. Proper archival handling of these digital objects should include tools to rapidly and selectively present to a human-relevant document segments for quality assurance in order to mitigate risk during subsequent archival and access events.

References

Adobe Developer Connection. (2009). Font technical notes. Retrieved December 18, 2009, from http://www.adobe.com/devnet/font.

Bauermeister, B. (1987). *A Manual of Comparative Typography.* New York US: Van Nostrand Reinhold.

Fanning, B. (2008). *Preserving the data explosion: Using PDF.* Digital Preservation Coalition Technology Watch Report 08-02. Silver Spring, MD: Digital Preservation Coalition and AIIM.

Impson, J. (2005). Evaluating the IBM and HP/PANOSE font classification systems. *Online Information Review 29, (5).* Bradford, West Yorkshire: MCB University Press.

Kaplan, M. (2009). *Font substitution and linking #1*. Retrieved December 18, 2009, from http://blogs.msdn.com/michkap/archive/2005/03/20/399322.aspx.

Lachowicz, D. (2009). *wvWare, library for converting Word documents*. Retrieved December 18, 2009, from http://wvware.sourceforge.net/.

Levy, D.M. (1998). Heroic measures: reflections on the possibility and purpose of digital preservation. In *DL '98: Proceedings of the third ACM conference on Digital libraries*. New York, NY, USA: ACM.

Microsoft (2006). *WPF font selection model*. Retrieved February 16, 2011, from http://blogs.msdn.com/b/text/archive/2007/04/23/wpf-font-selection-model.aspx.

Microsoft (2009). *DirectWrite API Reference.* Retrieved December 18, 2009, from http://msdn.microsoft.com/en-us/library/dd368038(VS.85).aspx.

Microsoft (2009a). *List of fonts supplied with Microsoft products.* Retrieved December 18, 2009, from http://www.microsoft.com/typography/fonts/product.aspx?PID=1.

Microsoft (2009b). *LOGFONT*. Retrieved December 18, 2009, from http://msdn.microsoft.com/en-us/library/ms901140.aspx.

Microsoft (2009c). *Microsoft Word 2007 binary format specification*. Retrieved December 18, 2009, from http://msdn.microsoft.com/en-us/library/cc313153.aspx.

Microsoft (2010a). *Unable to embed TrueType Fonts in OLE equation objects.* Retrieved November 29, 2010, from http://social.answers.microsoft.com/Forums/en-US/wordcreate/thread/0f05a908-5449-4dae-b7dc-57c05a9e42a0.

Reichherzer, T., and Brown, G. (2006). Quantifying software requirements for supporting archived office documents using emulation. In *JCDL '06: Proceedings of the 6th ACM/IEEE-CS joint conference on digital libraries*. New York, NY, USA: ACM.