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Modernizing Parametric type design

A case study of Nupuram Malayalam typeface

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Abstract: Parametric fonts are programatically defined fonts with variable parameters, pioneered by Donald Knuth with his METAFONT (Knuth, 1979) technology in the 80s. However, this approach has not gained widespread acceptance in mainstream type design due to the perceived need for close collaboration between designers and programmers to define the design mathematically. I explored the modernization of METAFONT based type design. METAPOST (Hobby, 1994), a successor of METAFONT, that can generate vector outputs, was used in this project. Mathematical descriptions of all the glyphs for Malayalam and Latin script are prepared in METAPOST, compiled to UFO type source and used modern font build tooling. The outcome of this endeavor is Nupuram, a versatile typeface super-family. Based on this experience, in this paper, I aim to present the technology, process, challenges, and learnings.

Keywords: Parametric design, Variable fonts, Opentype, Color fonts, METAFONT, METAPOST, Malayalam, Calligraphic font, Educational type design, Open source

1 Introduction

The contemporary type design process uses advanced graphical user interface(GUI) editors. These editors not only facilitate the design aspect but also streamline the entire workflow encompassing the creation of a fully functional typeface and its subsequent proofing. It is worth noting that these GUI-based tools often come at a substantial cost, are proprietary in nature, and in some cases, are dependent on specific operating systems. However, the genesis of digital type design predates the advent of these GUI design tools. Donald Knuth introduced the concept of programatically defining the shapes of letters in 80s (Knuth, 1979). Knuth approached the type design as a mathematical problem, positing that type designers could articulate mathematical definitions for letterforms. This paradigm, embodied in the METAFONT program, failed to get widespread traction beyond Knuth's own typefaces.

Knuth attributes this to the fact that “asking an artist to become enough of a mathematician to understand how to write a font with 60 parameters is too much.”(Knuth, 1985). Towards the latter part of the 1980s, GUI-based type design tools began to ascend in popularity, eventually establishing themselves as the de facto method for type design.

Nevertheless, certain foundational concepts introduced by Knuth have persisted and evolved over time. One such concept was the notion of generating multiple instances of a font by manipulating key parameters, a concept now recognized as variable fonts, which have garnered considerable popularity in contemporary typography.

In light of the fact that typefaces have evolved into increasingly complex software entities rather than mere digital renditions of calligraphic designs, the discipline of type design has undergone a transformation into a branch of software engineering. This transformation has necessitated that type designers either possess a working knowledge of software engineering and mathematical principles or collaborate closely with individuals skilled in the realm of ‘type engineering’.

As a professional with a background in software engineering who subsequently ventured into the realm of type design, I embarked on an endeavor to revisit METAFONT and integrate it with the modern type design workflow. The Nupuram Malayalam typeface project was born from this experiment. This paper serves as an exposition of the modernization approach, results and lessons learned.

2 Parametric design

The fundamental premise of parametric design revolves around the notion that design outcomes are governed by explicitly defined parameters. Altering these parameters independently yields distinct outputs without necessitating a complete redesign. METAFONT is a programming language that helps to define such designs.

2.1 METAFONT and METAPOST

Donald Knuth started work on font creation software in 1977, and produced the first version of METAFONT in 1979. Due to shortcomings in the original METAFONT language, Knuth developed an entirely new METAFONT system in 1984, and it is this revised system that is used today. The AMS Euler typeface was created by Hermann Zapf with the assistance of Donald Knuth using METAFONT. Computer Modern is another typeface created using METAFONT. METAFONT produces bitmap fonts that can be embedded in PostScript documents.



METAPOST is a graphic programming language developed by John Hobby that allows its user to produce high-quality graphics. METAPOST produces vector graphics from a geometric/algebraic description. The language shares METAFONT’s declarative syntax for manipulating lines, curves, points and geometric transformations. Unlike METAFONT, METAPOST can produce SVG output.

```

1  beginfig (1);
2  side:=10;
3  draw (0,0) -- (side,0) -- (side,side) --(0,side) -- (0,0);
4  endfig;

```

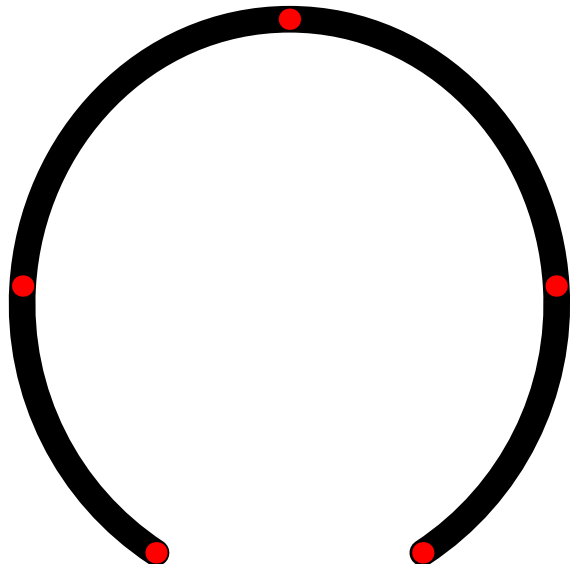
Listing 1: METAPOST code to draw a square

Listing 1 is an example METAPOST program. It produces a square like this.  Changing the value of *side* to say, 20, draws the same square with bigger size like this: . Here the *side* is a parameter to the design of square. By changing the value *side*, and without any other modification to the design, we produce distinct renditions. This is the simplest explanation of parametric design. Let us try to draw the Malayalam letter Ra.

```

1  beginfig (0);
2  width:=100; height:=100;
3
4  z0 = (x1 + width/4, 0);
5  z1 = (0, y0 + height/2);
6  z2 = (x1 + width/2, y1 + height/2);
7  z3 = (x2 + width/2, y1);
8  z4 = (x3 - width/4, y0);
9
10 pickup pencircle scaled 10;
11 draw z0..z1..z2..z3..z4;
12
13 % Add dots to indicate the points
14 pickup pencircle scaled 4;
15 for i=0 upto 4:
16     draw z[i] withcolor red;
17 endfor;
18 endfig;
19

```



Listing 2: METAPOST code to draw the Malayalam letter Ra

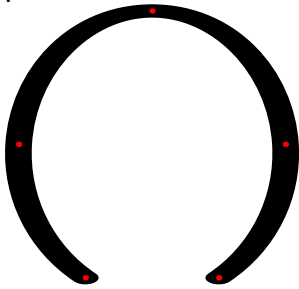
From the program Listing 2, we can see that we are drawing along the 5 points z_0 to z_4 and using curves to connect them. We are using a ‘pen’ called `pencircle scaled 10` times. `Pencircle` is just a circle and it will be moved along the curve and filled. There are *width* and *height* that controls the sweep of the arc too. There are other predefined pens like ‘pensquare’.

2.2 The Pens

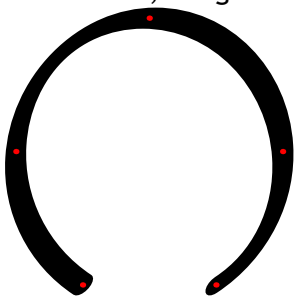
The concept of pens, also known as nibs are the powerful components of METAPOST. A pen could be of any shape¹. Let us use a `pencircle`, but deform it first by scaling 10 in x dimen-

¹Any convex polygon, to be precise.

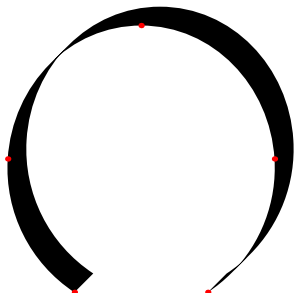
sion and 5 in y dimension. `pickup pencircle xscaled 10 yscaled 5` makes it an elliptical pen: ● Then if we move that pen along the same path, we get:



We can rotate this elliptical nib to an angle and use it as nib using `pickup pencircle xscaled 10 yscaled 5 rotated 45`. We get this nib: ● Now, if we draw the same shape using this slanted nib, we get:

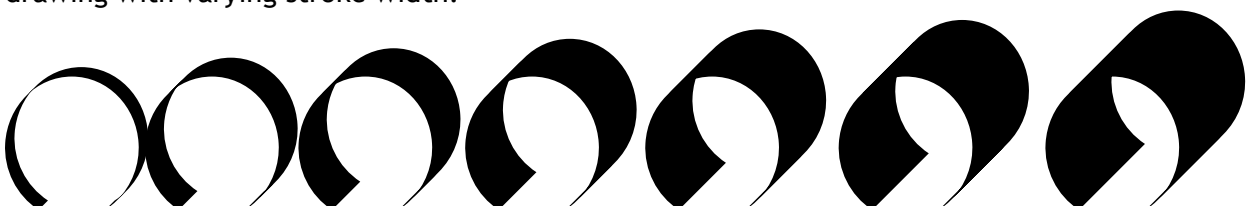


Let us attempt to define a broad nib calligraphy pen. They are straight lines without much thickness (we can assume 0 thickness, or razors), held at an angle like 40° or 45°. It will look like this: / If we draw with this calligraphy pen we get:



As we saw from examples above, we were able to produce a varying number of strokes from the simple pens defined. However, more complex character shapes, such as those found in serif fonts, cannot be adequately represented using pen strokes alone. One approach is to use a combination of different pens. Another approach is to draw the outlines directly instead of using the outline created using pens.


Not only the type of pen, but the aspects of pens can also be parameterized. For example, if we change the length of Calligraphic nib in previous example, we can generate the same drawing with varying stroke width:





This is particularly useful in type design to generate the weight variants like thin, light, regular, bold, black etc. Since each of the drawing will have exact number of nodes, they are easily interpolatable to generate a variable font with ‘weight’ axis.


2.3 The Curves

The `draw` command of METAPOST connects the points using straight lines or curves. The points are defined by coordinates in the form of (x, y) . Points connected using dots are curves ... Points connected using `--` are straight lines. `---` connect a straight line and curve with a smooth joint. So examples:

`draw (0, 0) -- (20,0) --(20, 10) ⇒` 

`draw (0, 0) .. (10,0) .. (20,0) ⇒` 

`draw (0, 0) -- (10,0) .. (20,0) ⇒` 

`draw (0, 0) --- (10,0) .. (20,0) ⇒` 

When METAPOST draws a smooth curve through a sequence of points, each pair of consecutive points is connected by a cubic Bézier curve, which needs, in order to be determined, two intermediate control points in addition to the end points. The points on the curved segment from points p_0 to p_1 with post control point c_0 and pre control point c_1 are determined by the formula

$$p(t) = (1-t)^3 p_0 + 3(1-t)^2 t c_0 + 3(1-t) t^2 c_1 + t^3 p_1$$

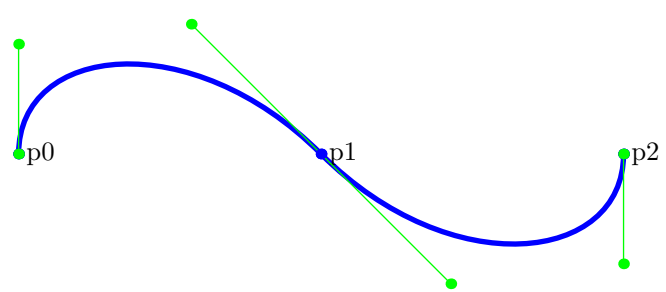
where $t \in [0, 1]$. METAPOST automatically calculates the control points such that the segments have the same direction at the interior knots.

In the Figure below, the additional control points are drawn as green dots and connected to their parent point with green line segments. The curve moves from the starting point p_0 in the direction of the post control point of p_0 , but bends after a while towards p_1 . The further away the post control point is, the longer the curve keeps this direction. Similarly, the curve arrives at a point coming from the direction of the pre control point. The further away the pre control point is, the earlier the curve gets this direction. It is as if the control points pull their parent point in a certain direction and the further away a control point is, the stronger it pulls.

```

1  beginfig(1);
2  u := 2cm;
3  pair p[];
4  p0 = (0,0); p1 = (2u,0); p2 =
    (4u,0);
5  path q; q := p0{dir 90}..p1..{dir
    90}p2;
6  draw q withpen pencircle scaled 2
    withcolor blue;
7
8  for i=0 upto length(q):
9      dotlabel.rt("p" & decimal(i),
10     point i of q);
11     draw point i of q
12     withpen pencircle scaled 4
13     withcolor blue;
14     p3 := precontrol i of q;
15     p4 := postcontrol i of q;
16     draw p3--p4 withcolor green;
17     draw p3 withpen pencircle
18     scaled 4 withcolor green;
19     draw p4 withpen pencircle
20     scaled 4 withcolor green;
21 endfor;
22 endfig

```




By default in METAPOST, the incoming and outgoing direction at a point on the curve are the same so that the curve is smooth. The algorithm behind the curve smoothing in METAPOST is developed by John D. Hobby.^{(Hobby, 1986)²}. METAPOST allows the control points to be specified directly in the following format:

```
draw (0,0)..controls (26.8,-1.8) and (51.4,14.6)..(60,40)
```

It is easy to adjust these control points in a GUI editor, but in METAPOST, we want to think about only the curves. For this, METAPOST provides a mechanism to declare the direction, tension and curl of the curves along with path expression.

```
draw (0, 0){dir 30}..{dir 45}(10, 10)..{right}(20, 0)..{dir 30}(30, 10) =
```



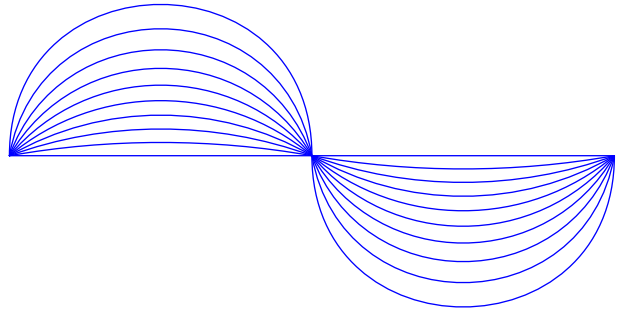
To illustrate how the direction specification changes the curves, let us plot curves with varying directions as below:

²The hobby package with Tikz package of L^AT_EX can also create similar smooth curves. Before developing the METAPOST based workflow, I had attempted creating SVGs using Tikz, however abandoned because of various reasons such as inflexible, SVG issues. <https://ctan.math.illinois.edu/graphics/pgf/contrib/hobby/hobby.pdf>

```

1 beginfig(0)
2 for a=0 upto 9:
3     draw (0,0){dir 10a}
4     ..{dir -10a}(4cm, 0)
5     ..{dir 10a}(8cm, 0) withcolor blue;
6 endfor
7 endfig;

```



METAPOST also allows to specify the tension and curl of the curves. Since they are not used in the Nupuram typeface and for brevity, we are skipping the explanation here.

2.4 SVGs from METAPOST

Latest version of METAPOST can output SVGs. The previous examples of rendering a glyph with different pens might make us believe that we can directly use those SVGs for using it in a font. However, a close inspection of the SVGs produced will disappoint us. Let us revisit the 'Ra' example:

In Figure 1a the white line is the path we defined and drew. The thick black line along that path is just the stroke width of the path. So this is an SVG with just 5 nodes. This is not an SVG we can use for type design. In a glyph, we need a closed outline. Our expected drawing should be as shown in Figure 1b:

While designing fonts with METAFONT Knuth outlines(Knuth, 1989) a method for 'envelope' calculation. Internally, in METAFONT all the pencircle are approximated a convex polygon with 24 sides. Then this polygon is used just like pensquare(that has 4 sides). Then the outlines of the polygon pen is calculated to get the 'envelope' or outline stroke. This works well for the METAFONT since it outputs bitmaps. But for METAPOST since the output is a vector image, and since we want the SVG a very clean vector with very minimal nodes, this solution has issues as we see in as shown in Figure 1c. It produces several unwanted

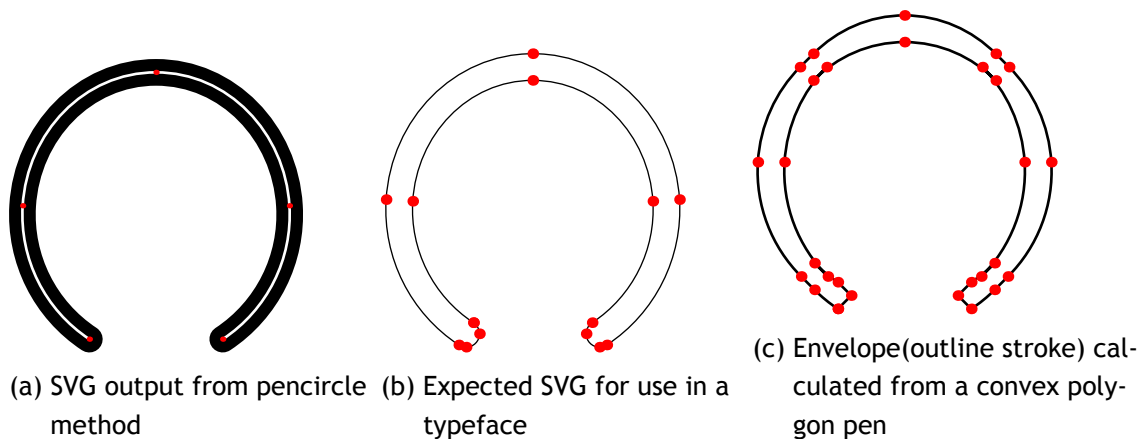


Figure 1: Comparison of SVGs produced by METAPOST

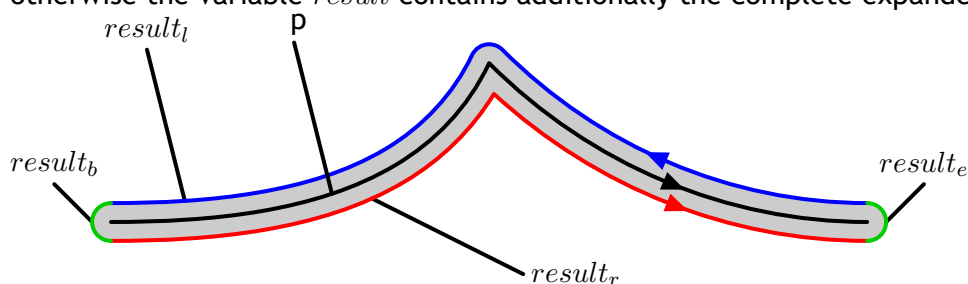
nodes and they are unpredictable when the parameters like width/height etc changed. We resolved this issues by using the macros provided by MetaType package.

2.5 MetaType

MetaType is a tool created by Bogusław Jackowski, Janusz Nowacki, and Piotr Strzelczyk for creating PostScript Type 1³ fonts (law Jackowski et al., 2001). MetaType was used to create the Latin Modern fonts, derived from Computer Modern fonts but including many more accented characters (law Jackowski and Nowacki, 2003). Most important fonts produced with MetaType1 are: Latin Modern, Latin Modern Math, TeX Gyre, Antykwa Toruńska, Antykwa Półtawskiego, Kurier and Iwona.

Even though we are not generating any PostScript fonts here, MetaType was very crucial in the development of workflow. The utility library as part of MetaType include many macros to produce accurate pen envelopes suitable for typefaces.

Nupuram project extensively used macro *pen_stroke* defined in MetaType. Macro *pen_stroke* performs an operation known as “expanding stroke”; we’ll call the result of the operation a “pen envelope” (for a given path). The macro has one optional parameter, *opts* (*text*), and two obligatory ones: input path *p* (*expr*) and a *result* (*suffix*). A user has an access to sub-paths of the envelope, namely: *result_r* is the right edge of the envelope, *result_l*—its left edge, *result_b*—is a fragment of the pen outline joining left and right edge of the envelope at the beginning node of the path, *result_e*—is a similar fragment at the ending node of the path (see the picture below). If the path *p* is cyclic, then *result_e* and *result_b* are undefined, otherwise the variable *result* contains additionally the complete expanded stroke.



For finding an envelope, a default path (*default_nib*, returned by *fix_nib*) is used except nodes for which the parameter *opts* sets another pen. Mastering the usage of the parameter *opts* allows a user to achieve nontrivial effects. The parameter *opts* is a list (space-separated or semicolon-separated) of the following operators: (1) *nib*, (2) *cut*, (3) *tip*, and (4) *ignore_directions*.

The macro *nib* has two parameters: *nib*(*pen*)(*list_of_nodes*), where ‘*pen*’ is a path returned by macro *fix_nib*, and ‘*list_of_nodes*’ contains comma-separated numbers (times) of the nodes of the path *p* at which a given pen is to be used.

³Type 1 fonts are a legacy format created by Adobe in 1984

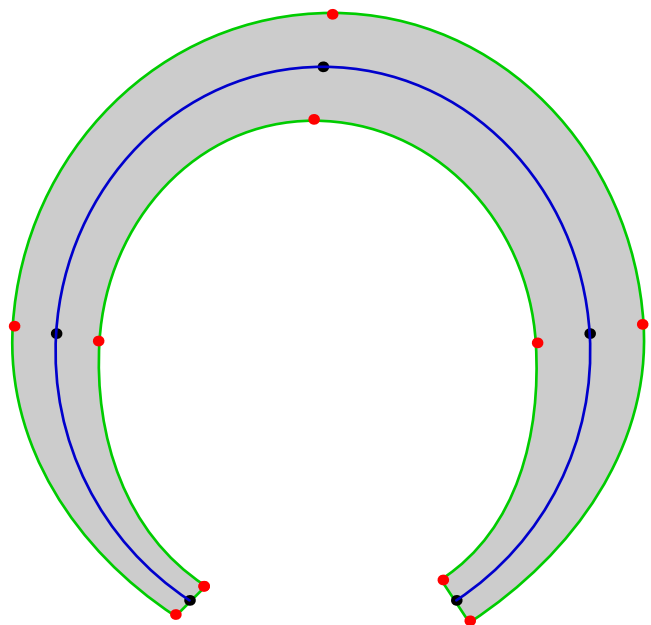
To illustrate this, let us revisit the same arc examples. As shown below, by using the *pen_stroke* macro and using different pens at different nodes in the path, we get a perfect vector output. We can see the arc is drawn using 5 points. And corresponding to each node, 2 nodes are present in the outline stroke, on outer and inner side of outline stroke. Depending on the pen thickness at each node, we get smooth curves that vary the thickness.

The resulting stroke modulation, its extrapolatable nature with respect to the parameters like nib thickness are the key tools to build a typeface, potentially a variable typeface. The terminals can be a cut at any angle or any nib at any angle or width. Each node in the path can be any nib at any width, shape and angle.

```

1  input plain_ex;
2  beginfig(0);
3  width:=200;    height:=200;
4  thick:=width/5; thin:=thick*2/3;
5  % .. path definition goes here ..
6  path p, s; p := z0..z1..z2..z3..z4;
7
8  vardef thicknib = fix_nib(thick, 0, 0)
9  enddef;
10 vardef thinnib = fix_nib(thin, 0, 0)
11 enddef;
12 pen_stroke(
13   cut(thinnib, 45)(0)
14   nib(thinnib scaled 1.2 rotated
15   -10)(1)
16   nib(thicknib rotated 80)(2)
17   nib(thicknib rotated 10)(3)
18   cut(thinnib scaled 1.25, rel 90)
19   (4)
20 ) (p)(s);
21 draw s withpen pencircle scaled 1;
22 fill s withcolor .8white;
23 endfig;

```



Listing 3: Usage of *pen_stroke* macro.

3 Earlier attempts

Although METAFONT never became mainstream, hundreds of fonts have been created with it: an incredible list has been compiled by Luc Devroye⁴.

Jeroen Hellingman created Malayalam metafonts in 1994 (Hellingman, 1998). These were created as uniform strokes. Karel Piska later converted all these fonts to Type1 fonts. He

⁴List of fonts created using METAFONT. Compiled by Luc Devroye. <http://luc.devroye.org/metafont.html>

did this by an accurate analytic conversion to outlines using METAPOST output. After theoretical conversion, the FontForge is used for removing overlap, simplification, rounding to integer, autohinting, generating outline fonts, and necessary manual modifications.⁵

4 Modern typeface design workflow with METAPOST

As we explained earlier, the first step is to define the glyphs using METAPOST. Then we compile them to SVGs. These SVGs are then converted to glif format of Unified Font Object format⁶. The Unified Font Object (UFO) is a cross-platform, cross-application, human readable, future proof format for storing font data. This is the modern format used by type-designers. Type design tools offer a feature to export their internal format to UFO too⁷.

Once we have UFO formatted font source, we need to write the Opentype features and save it as part of same UFO file. Then type compiling tools like fontmake⁸ can compile this UFO to a font binary such as .ttf, .otf or webfonts. The opentype features, glyph to unicode mapping, kerning and font meta information - these are all part of the prepared UFO. A set of programs prepares all of these based on a simple configuration file.

Preparing the opentype features used to be a major task for typeface design for Malayalam. We used to manually write them. In Nupuram typeface they are automatically generated based on the script grammar encoded in application logic.⁹ For a script Malayalam, Opentype rules are integral part of typeface. Rapid experimentation and variation generation with Nupuram was possible because of auto-generation of opentype rules.

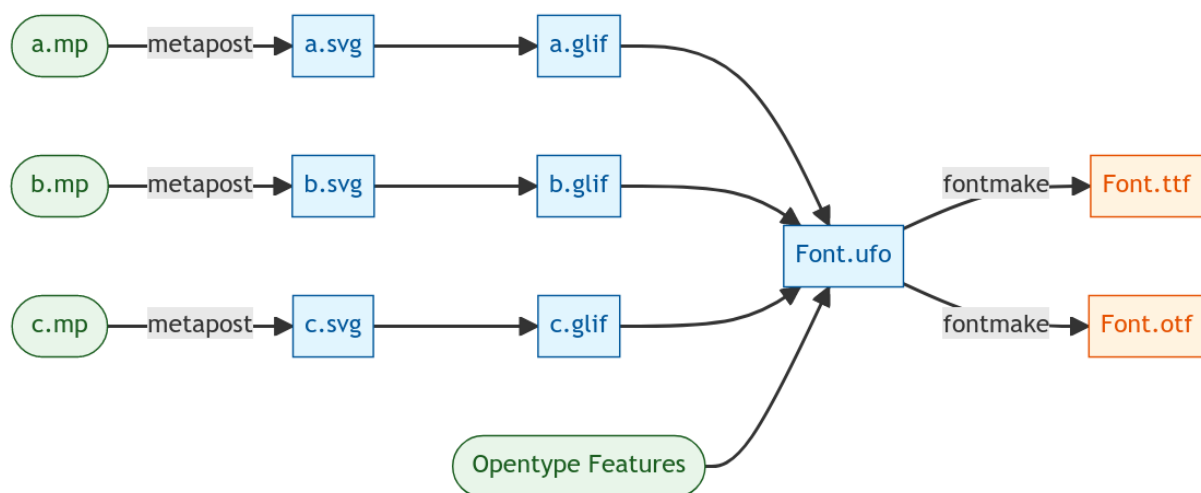


Figure 2: Highlevel workflow of type design with METAPOST

⁵CTAN: indic-type1 - Indic Type 1 fonts converted from public METAFONT sources <https://ctan.org/pkg/indic-type1>

⁶<https://unifiedfontobject.org/versions/ufo3/>

⁷For example, Glyphs application's .glyphs format can be converted to ufo format.

⁸fontmake : <https://github.com/googlefonts/fontmake>

⁹Source code repository of Nupuram <https://gitlab.com/smc/fonts/Nupuram>



Figure 3: Vilakkum Velichavum title design by SA Nair.

5 Nupuram Type Family

5.1 Design

Nupuram¹⁰ draws the inspiration from the title posters of early Malayalam movies around 1960-1970, particularly those crafted by the renowned title designer, S Appukkuttan Nair (Popularly known as SA Nair)¹¹. These title designs features letterforms with wide, flat, sharp terminals, thin vertical strokes and thick horizontal strokes.¹² Even though there are hundreds of posters done by SA Nair with same design concept, there is no strict uniformity in these designs due to their entirely handmade nature. Adapting these distinctive traits to a typeface required many customization. In this endeavor, while I departed from the pronounced sharpness of the terminals, I preserved the broad strokes while slightly reducing their thickness.

The vertical stems in glyphs are thin and horizontal ones are thick, akin to the characteristics of reverse contrast typefaces. The letters are close to handwritten style than a regular print style. One can easily notice the playful, casual, personal aesthetic. Usable at display and text sizes too.

Based on the macros we explained in Section 2.5, the nibs of Nupuram glyphs are defined. There are three 3 nibs - *thicknib*, *thinnib* and *terminalnib*. Here, *thicknib*, *thinnib* are razors nibs or nibs with 0 width. Their lengths are parameterized. *terminalnib* is a razor nib or an elliptical nib based on whether terminal are rounded(soft) or flat(sharp).

¹⁰The word Nupuram means ‘anklet’ <https://en.wikipedia.org/wiki/Anklet>

¹¹SA Nair, Malayalam Movie and Music Database <https://m3db.com/sa-nair>

¹²Examples: Thakilu Kottampuram(<https://m3db.com/film/thakilu-kottampuram>), Vilakkum Velichavum (<https://m3db.com/film/vilakkum-velichavum>), Angadi(<https://m3db.com/film/angadi>)

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Figure 4: Nupuram design

5.2 Typographic units

The nib length(that results the thickness of strokes) is defined by *thick* and *thin* configuration. The value *thick* is expressed in relationship with EM Size. the emsize is defined as $em := 1000$. Then this Em value is divided to basic typography units, defined as $u := em/10$. The *u* is the unit we will use to define all typographic parameters such as ascent, descent, bearing, thick, thin etc.

```
1  em :=          1000;          % Height of characters - Em square
2  u :=          em/10;          % Unit width. Em square divisions.
3  ascent :=      8u;            % Ascender Height
4  descent :=     2u;            % Descender Height
5  xheight :=     2/3*ascent;    % Height of English small letters
6  mheight :=     3/4*ascent;    % Height of Malayalam letters
7  Xheight :=     8u;            % Height of English capital letters
8  thick :=       1u;            % Thickness of thickest lines
9  thin :=        0.7;           % Thickness of thinnest lines-ratio of thick.
10 subthick :=    0.666u;        % Thickness of thickest lines in subscribed
    characters
11 xthick :=       1;            % Extra thickness for terminals
12 slant :=        0;            % Slant of characters.Give angle values
13 condense :=     1;            % Condense factor. < 1 for condense, > 1 for
    expand
14 lbearing :=     0.4u;         % Default left bearing
15 rbearing :=     0.4u;         % Default right bearing
16
```

Listing 4: Basic typographic parameters defined in Nupuram typeface

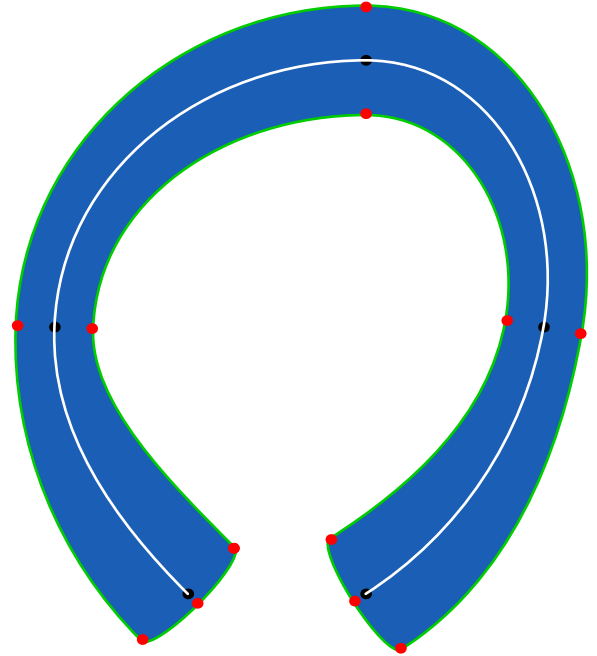
By changing any of these base parameters we can build a new design. But not all changes produce a good or useful design. To make a typeface with weight variants, we change the *thick* parameter alone. To change the extra thickness of terminals we change the *xthick* parameter. To get a slanted glyph with 15° , we give $slant = 15$ and so on. We will discuss this in detail in next section about variable fonts.

Using all these parameters let us try to draw the letter 'Ra', but this time as per the Nupuram design. See Listing 5

```

1 input plain_ex;
2 beginfig(0);
3 width:=200; height:=200; thick:=width/5;
4 thin:=0.7; m:=width; xthick:=1.1;
5 terminalround:=0.5;
6 z0=(x1 + m/4 , 0); z1=(0, m/2);
7 z2=(x0 + m/3, y1 + m/2); z3=(x2 + m/3, y2-m/2);
8 z4=(x2, 0);
9 path p,s; p:=z0{dir 135}..z1.. z2{right}..z3{dir
    260}..z4;
10
11 vardef thickenib = fix_nib(thick, thick, 0) enddef;
12 vardef thinnib = fix_nib(thick*thin, thick*thin,
    0) enddef;
13 vardef terminalnib = fix_nib(thick*xthick, thick*
    terminalround, 0) xyscaled(xthick,
    terminalround) enddef;
14 vardef terminalangle expr t of p = angle(direction
    t of p)+90 enddef;
15 pen_stroke(
16     nib(thinnib)(1,3) nib(thickenib)(2)
17     nib(terminalnib rotated terminalangle 0 of p)
    (0)
18     nib(terminalnib rotated terminalangle 4 of p)
    (4)
19 )(p)(s);
20 draw s; fill s;
21 endfig;
22

```



Listing 5: The ‘Ra’ letter in Nupuram.

5.3 Variable fonts

The glyphs and their variations are fully controllable by simple configurations files. On top of this common configurations, we define font specific variations in simple configuration files. For example, the configuration for creating Nupuram-Bold font will look like this

```

1 input ./config/Regular;
2 thick:= 1.25u;
3

```



It imports/includes the Regular configuration and set *thick* = 1.25*u*. You will quickly see that it is an increase on the *thick* value set in the configuration for ‘Regular’ variant

```

1    thick := 0.90u;
2    soften := 0;
3

```



Let us look at configuration for Nupuram Thin variant by setting *thick* = 0.5u.

```

1    input ./config/Regular;
2    thick := 0.5u;
3

```



Similarly, the configuration for Nupuram Condensed is defined by setting *condense* := 0.8

```

1    input ./config/Regular;
2    condense := 0.8;
3

```



An oblique variant will have the following configuration *slant* := 15

```

1    input ./config/Regular;
2    slant :=15; % Degree of slanting
3

```



Whether the terminals are flat(sharp edge) or rounded(smooth) is controlled by the *terminalnib* that uses *terminalround* parameters. By setting it *terminalround* := 0.15 we can get sharp terminal.¹³

```

1    input ./config/Regular;
2    terminalround:=0.15;
3

```



Since all of the above variants are same design, with exact number of SVG nodes and same curves, they are interpolatable. We can use them as master designs in a variable fonts designspace and get a variable font with ‘weight’, ‘width’, ‘slant’ and ‘soft’ axis.

All the 4 axes can be considered as a 4 dimensional space. By carefully choosing the values of any of these 4 axis, we can practically produce infinite styles. Modern typesetting softwares, Web pages(CSS) allow selecting this style by quick previews. Even though a user can

¹³Note that we are not setting it to 0 because, at zero the curve segment at terminal becomes a straight line. This affects the interpolation. We can only do interpolation of curve with another curve with more or less curl

Table 1: Nupuram variation axis tags, their ranges, default, and descriptions

Axis	Tag	Range	Default	Description
Weight	wght	100 to 900	400	Thin to Black. Can be defined with <code>font-weight</code> CSS property.
Slant	slnt	-15 to 0	0	Upright (0°) to Slanted (about 15°).
Width	wdth	75 to 125	100	Condensed to Expanded. Can be defined with usual <code>font-stretch</code> CSS property.
Soft	SOFT	0 to 100	50	Sharp to normal to SuperSoft terminals.

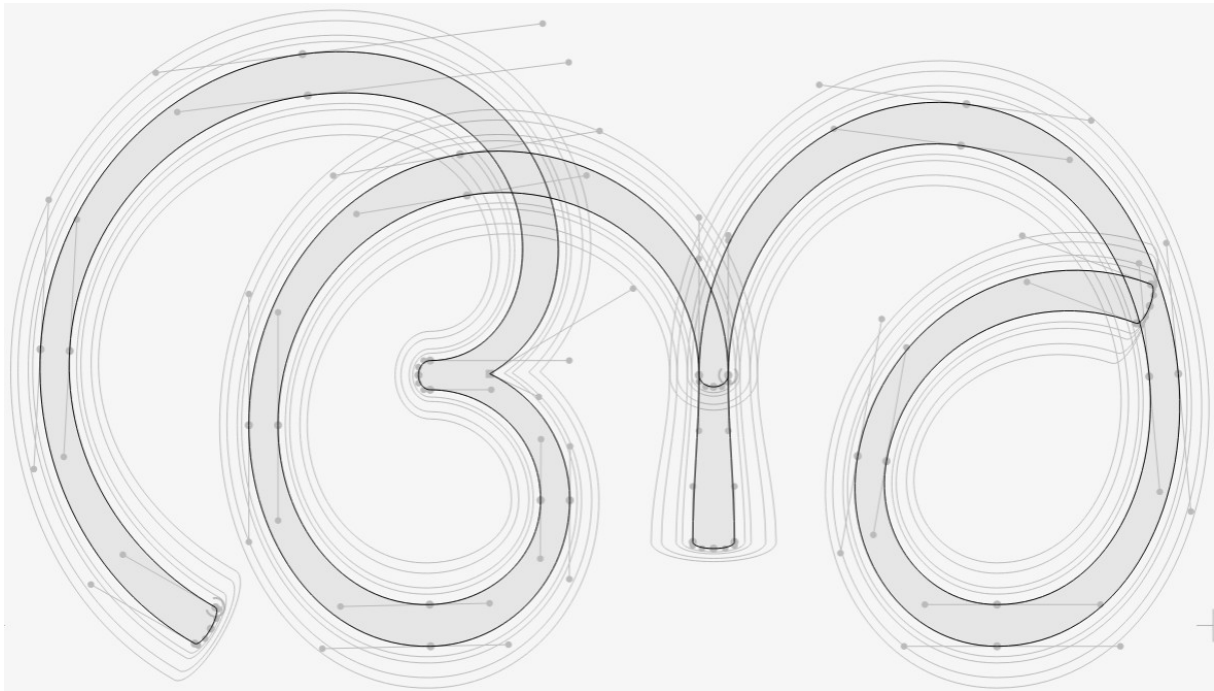


Figure 5: Visualization of Nupuram `wght` axis. The thickness of strokes varies here.

choose any of these styles, the typeface also comes with a predefined ‘named instances’ which are predefined combination of these values. For example, ‘Nupuram Condensed Thin’ is a named instance that choose ‘width’ and ‘weight’ axis value as ‘Condensed’ and ‘Thin’. Nupuram has 32 such named instances.

Nupuram is the first variable font in Malayalam with 4 design axes.

5.4 Debugging and proofing

Advanced GUI based font editors usually has advanced preview and proofing systems integrated. This is also an essential requirement for any type design system. While designing Nupuram, I used Visual Studio programming IDE along with live preview of SVGs. Figure 8 shows an example setup. In development mode, on top of the glyphs, guidelines, coordinates, points are also visualized to help the design process.

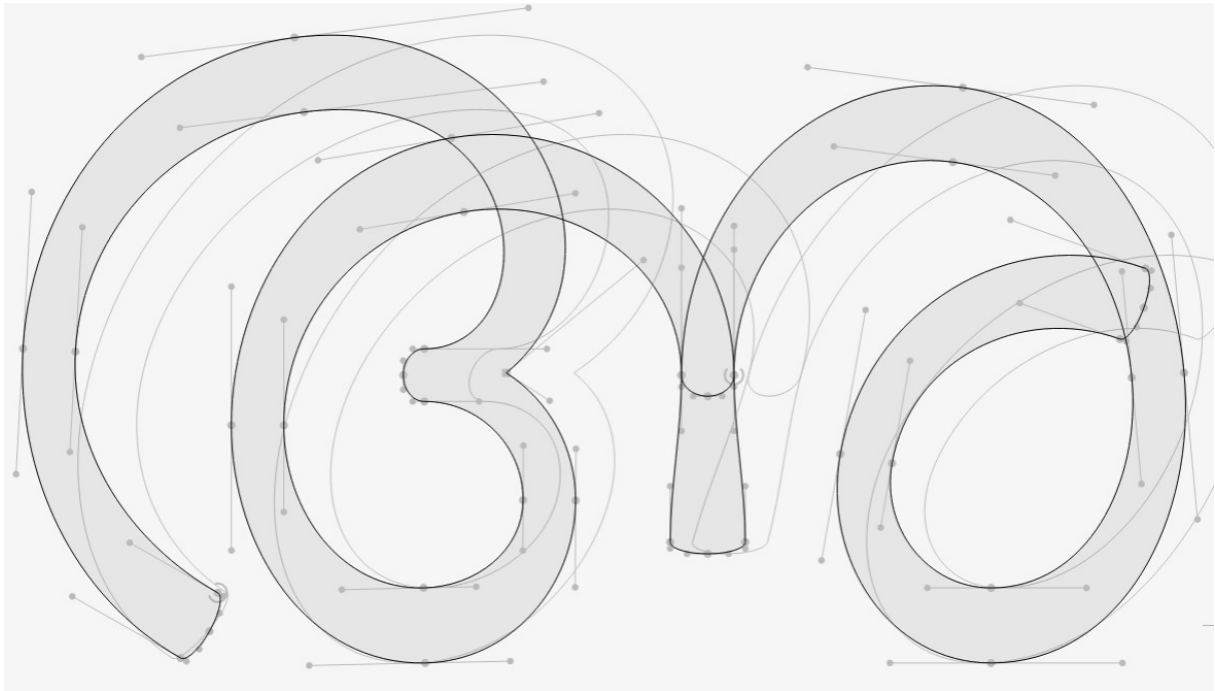


Figure 6: Visualization of Nupuram `slnt` axis. The slant angle changes from 0° to -15° .

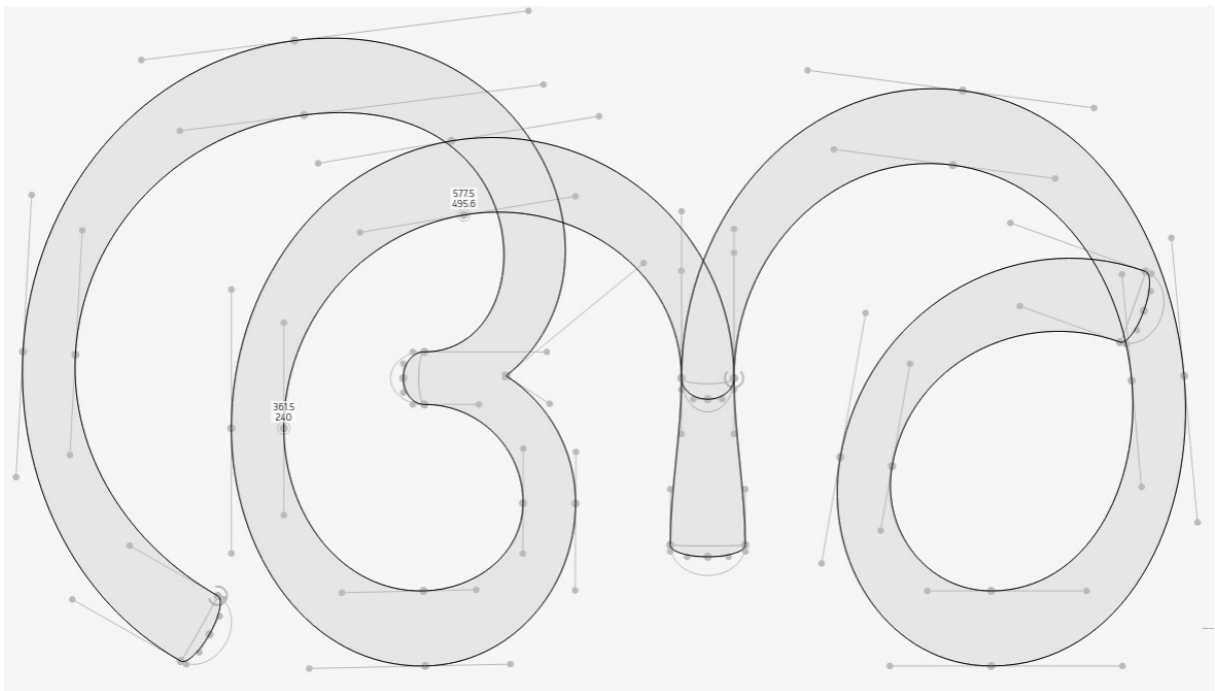


Figure 7: Visualization of Nupuram `SOFT` axis. The sharpness or softness varies from 0 to 100

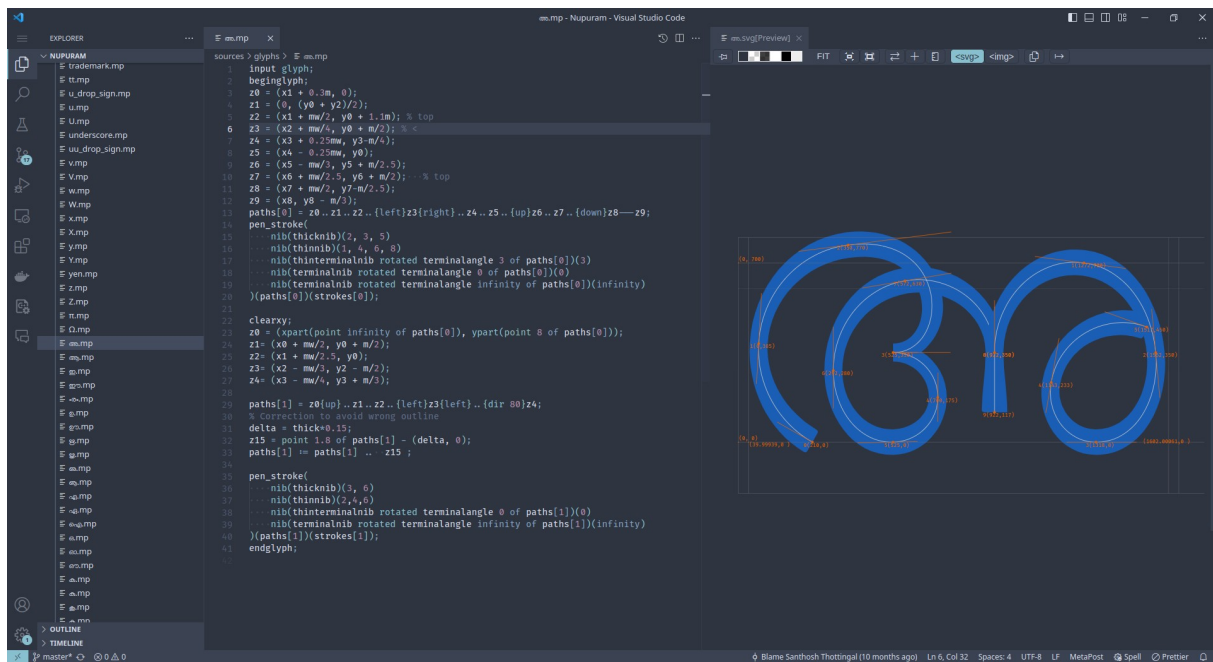


Figure 8: An example typedesign setup with VS Code IDE with METAFONT and SVG generated shown side by side. Changing the code automatically refreshes the image.

However, we also need more advanced proofing system to render an arbitrary text content with the given font to evaluate and fine tune various design aspects. For this, I developed a webbased type test and preview system¹⁴. See Figure 9

To ensure the quality of glyphs and various technical details to be taken care for a production ready typeface, automatic testing is incorporated using fontbakery tool¹⁵.

5.5 Latin glyphs

All the Malayalam characters defined in Unicode version 15 are present in the font. Nupuram also has latin script support. Nupuram supports 294 languages covering approximately 2.8B speakers¹⁶

The latin glyphs follow the same design of Malayalam. See Figure 10

5.6 Nupuram Calligraphy

Nupuram Calligraphy simulates a wide nib Calligraphy pen with nib rotation at 40°. This is a variable font with ‘weight’ axis. The width of the calligraphy pen can be varied for getting different weights. The width of the nib can be varied as required. So by defining 3 widths, narrow, medium, wide, we can get 3 variants of this glyph. Using these master glyphs, we

¹⁴This online tool is available at <https://smc.gitlab.io/fonts/Nupuram/tests/>

¹⁵fontbakery: A font quality assurance tool <https://github.com/fonttools/fontbakery>

¹⁶Calculated using hyperglot tool <https://hyperglot.rosettatype.com/>

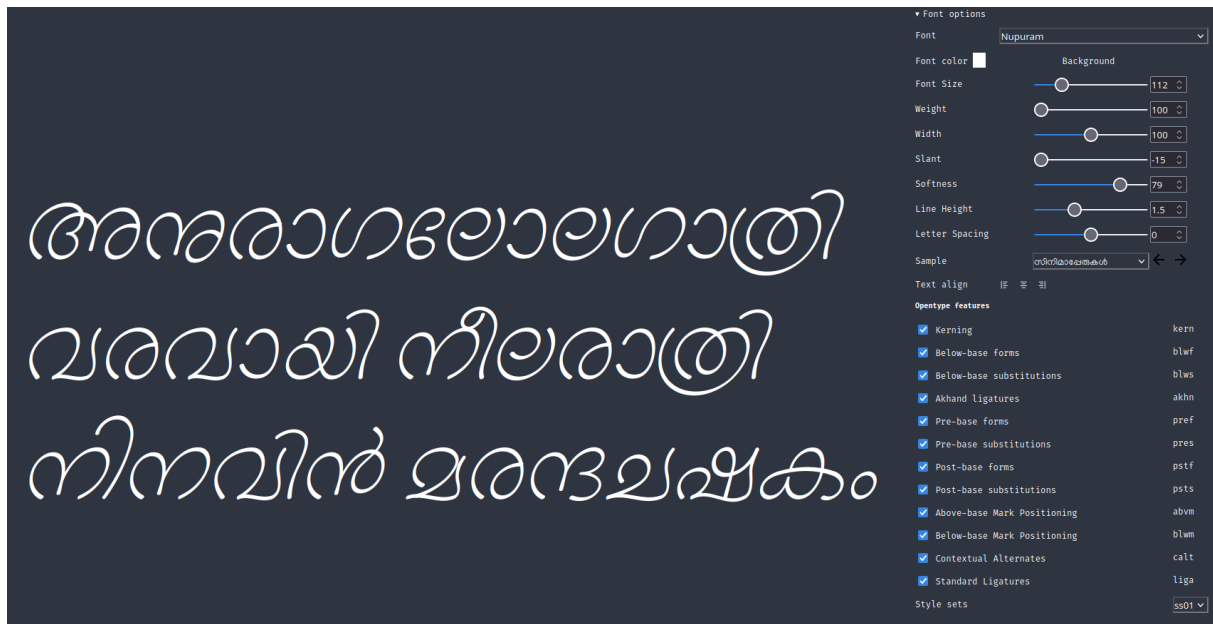


Figure 9: web based type testing, proofing, playground used in the Nupuram design process

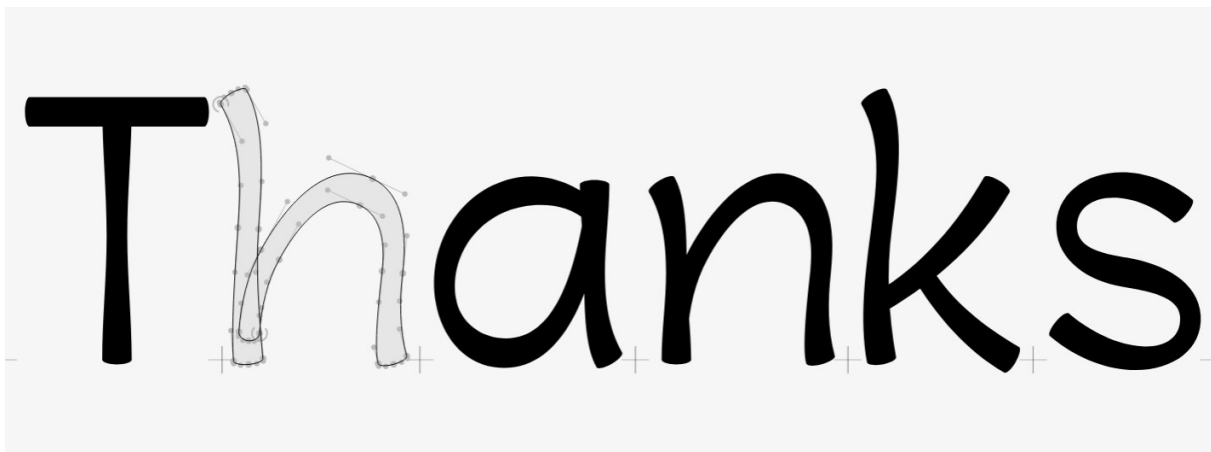


Figure 10: Nupuram English sample

The Earth is a very small stage in a vast cosmic arena. Think of the rivers of blood spilled by all those generals and emperors so that, in glory and triumph, they could become momentary masters of a fraction of a dot. Think of the endless visited by the inhabitants of one corner of this pixel the scarcely distinguishable inhabitants of some other corner, how frequent their misunderstandings, how eager they are to kill one another, how fervent their hatreds. The Earth is the only world known so far to harbor life. There is nowhere else, at least in the near future, to which our species could migrate.

Figure 11: Nupuram sample English paragraph

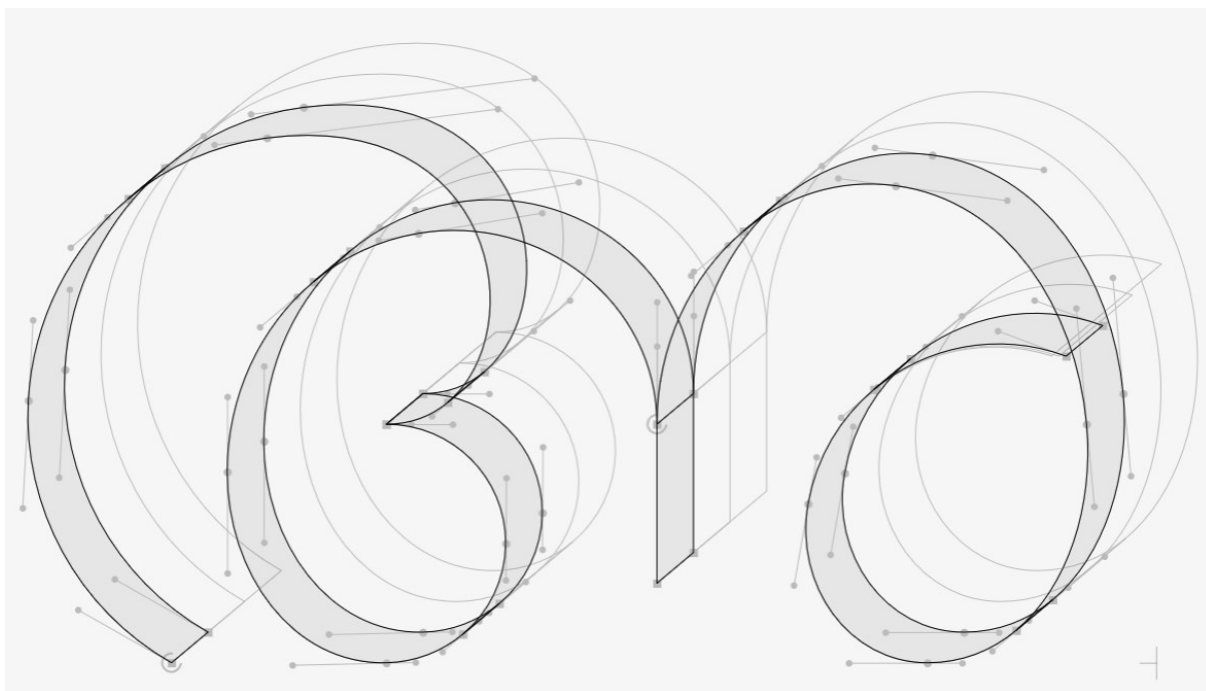


Figure 12: Weight axis variations of Nupuram Calligraphy subfamily



Figure 13: Nupuram Calligraphy sample

can interpolate to any nib size using the variable font technology. That is how we made Nupurum Calligraphy variable font. An illustration of weight axis variations is given in Figure 12

5.7 Nupuram Color

Color fonts (also known as chromatic fonts) can use multiple colors, including gradients, in a single glyph, rather than the flat, single color used by typical, non-color (monochromatic) fonts. This relatively new technology allows designers to set the color palette within the font to express themselves with color in a way that would previously not be possible outside of advanced graphics applications.¹⁷ Nupuram has a Color font version with COLRV1 specification. The colors can be customized by users, for example using CSS. Nupuram Color is also a variable font with customizable ‘wght’ axis.

Nupuram Color creates a solid 3D objects illusion. The anatomy of color font is based on an observation in Nupuram Calligraphy. In the calligraphy variant, we moved a calligraphic

¹⁷Introducing color fonts, Rod Sheeter https://fonts.google.com/knowledge/introducing_type/introducing_color_fonts



Figure 14: Sample rendering of Nupuram color font with default color palette

pen through the glyph path. If we use pen strokes with thick and thin strokes as explained earlier, we get a modulated glyph outline as Figure 15a. If the calligraphic pen we used for Nupuram Calligraphy is move through the outline, we will get Figure 15b

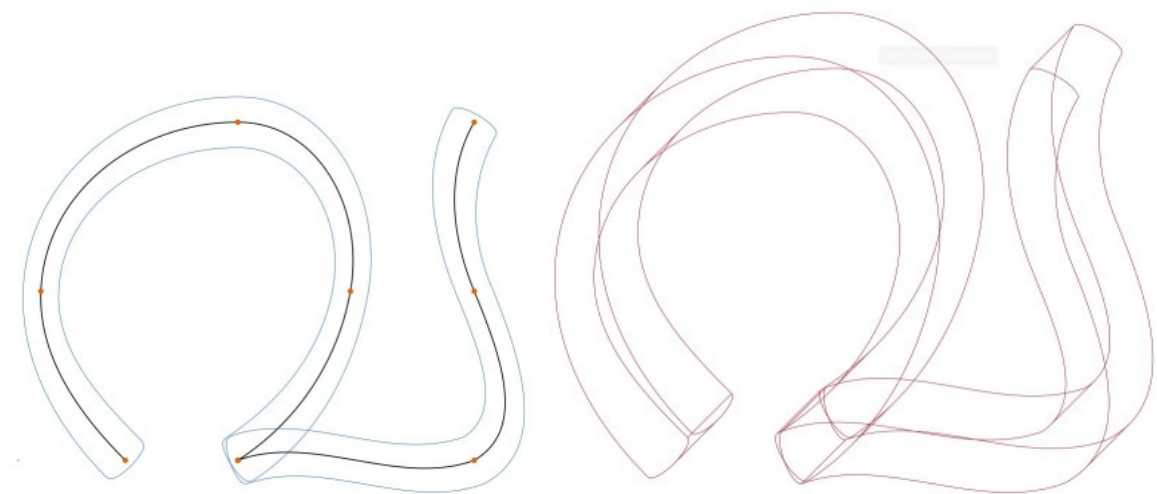
It is slightly confusing drawing, but we start to see a 3D shape in it. Let us fill this with color blue to get a better picture. See Figure 15c. Now we can relate this with the calligraphy glyph we constructed earlier. Same stroke modulation, but two times - for outer and inner lines.

If we look at 15c carefully, this is a 3D structure, but a hollow one. The facing size and backside is void, creating a hollow structure. To get a solid 3d shape, let us take the envelope of the whole drawing. What I mean by that is, to take the outline of this structure. See Figure 15d

Now it is not hollow. If you look carefully, you will see it is a 3D letter of 'va'. But to help your eyes for the 3D perspective it need colors, or lighting to get the depth perspective. To start with let us place our original 'va' outline on top of it in a lighter color. And Let us make the lighting and coloring a bit more realistic by using color gradients. We get the final rendering as Figure 15f

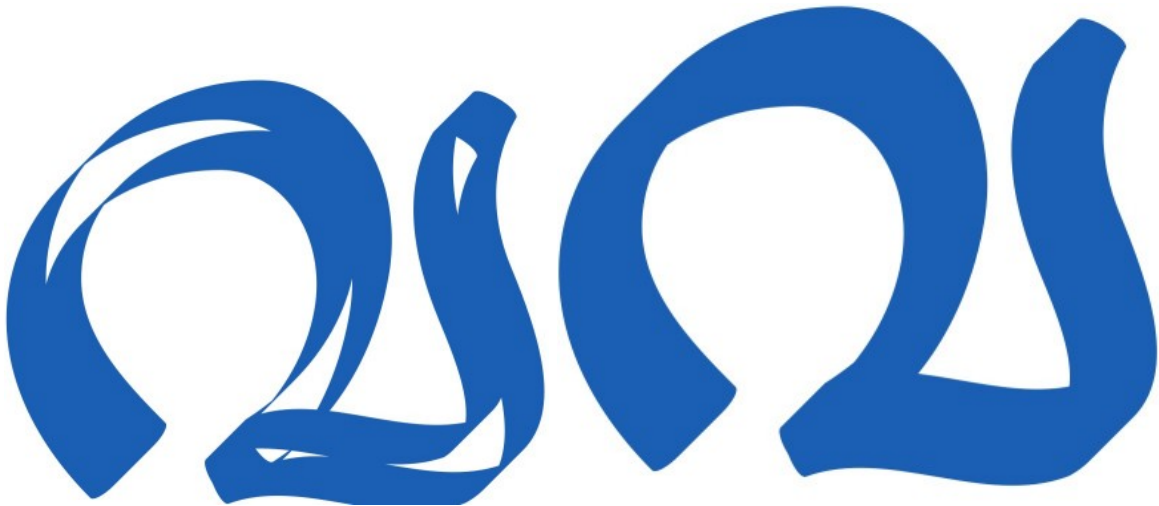
Nupuram Color font gives 18 predefined pallettes that can be selected by users. Or a user can specify the colors using CSS for example. This color font uses 3 colors for its shadow-ish look. They are Dark, Light, Base colors. Base is the facing color, Light is the central glowing area color. Dark is the color for the shadow part. The colors are used to create a gradient internally.

Nupuram is the first color font in Malayalam.



(a) Letter 'va' with pen stroke and outlines.

(b) Moving calligraphy nib along the outline



(c) Figure 15c filled with color.

(d) Envelope of Figure 15c



(e) Nupuram regular placed on top of Figure 15d

(f) Color gradients applied on Figure 15e. Final rendering.

Figure 15: Construction of Nupuram Color glyph

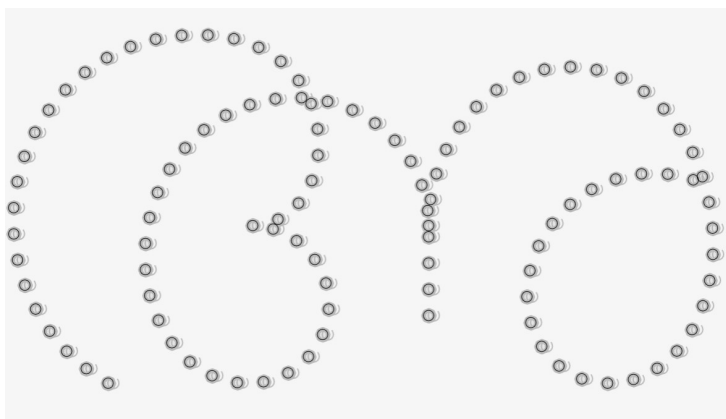


Figure 16: Nupuram Dots - an font for learning to write.

Each glyph in Nupuram color is constructed by two layers. The facing layer is Nupuram Regular. The background layer is constructed using the techniques explained above. Then each of these layered glyphs are compiles to a UFO. For each layer we define a linear gradient from top to middle and then reflect vertically. By chosing related colors for the gradients in front and background layers, we get the illusion of a 3D object illuminated. This kind of sophisticated glyph manipulation and generation of layers was possible because of META-POST's easy experimentation and variant generation. Drawing each of these glyphs by hand in a GUI environment would be quite tiresome and would take months of effort.

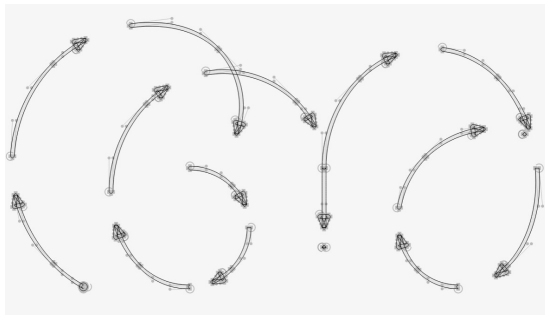
5.8 Nupuram Dots and Arrows

Since a pen could be any shape that can over a predefined path, one experiment I did in Nupuram is to produce a variant where the paths are filled with equally placed dots. We get a dotted font, often used in educational context - to learn how to write a letter by writing on top of it. We call this variant Nupuram Dots. See Figure 16

I tried to replace dots with arrows to indicate the writing direction. These arrows are equally placed on the pen path. See Figure 17a. To make it more useful, I placed the arrows font on top of the regular font. And gave two colors for each layer making it a color font. This color can be customized at user side like we explained in the section about Nupuram color. See Figure 17b

Special fonts like dot fonts play a valuable role in facilitating the process of learning to write letters, especially for young learners and those with fine motor skill challenges. By tracing arrows or connecting the dots, students develop muscle memory and hand-eye co-ordination necessary for proper letter formation. Dot fonts are particularly popular in early childhood education, where they help children transition from drawing shapes to writing letters.

Developing a dots or arrow font like this is a full-blown typeface project in common typeface design approach. Here, we see that it is a quick derivation of an existing typeface.



(a) Nupuram Arrows - Showing writing direction



(b) Nupuram arrows color font with default color palette.

Figure 17: Nupuram Arrows

6 Lessons

Parametric approach helped me to do easy experimentation. Traditional typesetting approach is not flexible once the key typographic metrics are fixed. In METAPOST based approach, finetuning these parameters is possible at any stage of the project. It is very easy to experiment with different parameters and pick one that is satisfactory to the designer. Sometimes these experiments also reveals surprising results. The approach for 3D like color font was born from such an experiment.

Leveraging my background as a software engineer, adept at working with source code, I found that applying this familiar paradigm to type design significantly enhanced productivity. Shapes were manipulated as modularized methods within the source code, and this modular approach proved instrumental in generating design outputs that were not only consistent but also coherent. This marked a notable departure from the challenges I had encountered in traditional typeface design projects in the past, where maintaining consistency and cohesiveness had often been a struggle.

Producing a superfamily of Malayalam typeface with multiple variable and color fonts can easily take multiple years of effort, and the collaboration of multiple individuals. However majority of Nupuram's work was finished in my free time in 6 months.

Capturing the details of all required glyphs and their opentype features in program was not an easy task, but that is an investment for future fonts. I could reuse most of the METAPOST code and the framework in a new typeface project¹⁸.

The ability to define the design precisely in mathematical language will guide the designer for stringent mathematical proportions for letterforms. Nevertheless, it is essential to recognize that such precision does not inherently guarantee the production of aesthetically pleasing glyphs. This tension between mathematical precision and aesthetic appeal emerged as a recurring theme throughout my type design process. For example, the programmer's

¹⁸Malini is a new typeface project that the author working on with METAPOST based workflow <https://github.com/smc/malini>

inclination to align an element exactly at the 0.5 mark of the entire width versus the more subjective choice of proportions that align with visual harmony and appeal.

The ability to swiftly generate variations and, consequently, produce variable fonts proved to be a significant advantage in my work. As an advocate of free and open-source principles, my objective was to construct the entire type design workflow and develop typefaces without relying on proprietary software. Notably, at the time, there was a lack of reliable free software tools for typeface design tailored to the creation of variable fonts. I overcame that limitation with this new workflow. Nupuram is one of the early color fonts after publishing opentype colrv1 specification. It is worth noting that the support for variable and color fonts are yet to catchup in common software application people use.

It is tempting to proliferate numerous subfamilies from a single typeface due to the ease of doing so. In this regard, it is pertinent to recall Knuth's cautionary advice regarding this issue. In the Nupuram project, driven by a desire to explore the myriad possibilities, I did create numerous subfamilies. Nevertheless, it remains a verifiable fact that an abundance of variations does not necessarily equate to an abundance of genuinely useful fonts.

I must acknowledge that METAPOST is not a programming language one can easily learn. It diverges significantly from the conventions of popular programming languages, presenting a distinctive learning curve. While valuable documentation resources do exist, there is a noticeable dearth of practical examples that designers can readily reference and learn from. Given this challenge, prior to advocating for the adoption of this workflow among fellow type designers, I recognized the need to address this limitation. So I documented Nupuram extensively. The project is published in free and opensource license for anybody to refer and learn¹⁹. I created a simple METAPOST playground website m.post.thottingal.in where people can quickly write METAPOST code and preview the result. I started a repository of various type design concepts illustrated using METAPOST²⁰.

Upon embarking on this exploration using METAPOST, I encountered several articles outlining why METAPOST or METAFONT did not catchup. A recurring theme in these discussions was the debate over whether an arbitrary typedesign can be expressed by the pen based approach where outlines are essentially the outputs of pen strokes. It is undeniable that outline-based design has established itself as a tried-and-true, successful design methodology, and this criticism is indeed grounded in validity. However, I contend that there is no inherent necessity for the exclusive use of pen-based design in every aspect of glyph creation. Whether it manifests as a stroke path or an outline, it essentially boils down to an array of coordinates from my perspective. The manipulation of arrays is a skill that I have honed as a programmer. For example, The serif shape for a latin letter cannot be created using the outlines of a pen. But nothing prevents a METAPOST programmer to quickly draw that outline without a pen definition.

¹⁹Nupuram source code repository: <https://github.com/smc/nupuram>. Licensed under SIL Open Font License, Version 1.1

²⁰Typeface design concepts illustrated using METAPOST <https://github.com/santhoshtr/type-concepts>

7 Conclusion

In this paper, I have provided an exhaustive exposition of the parametric type design methodology, using the Nupuram typeface as an illustrative example. Moreover, I elaborated the lessons learned. While this new approach enabled me to create a typeface with many features hitherto deemed unattainable, it is important to underscore that I am not proposing it as a replacement for the existing type design workflow. The approach outlined here is suitable for designers who possess proficiency in software engineering. As typefaces are becoming sophisticated software these days, I am hopeful that this approach will find utility among a broader spectrum of designers. Furthermore, I aspire to see the Nupuram typeface, born from this exploration, become a valuable asset for a diverse community of users.

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