Two issues with GSUB/GPOS conditions

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August 8, 2023

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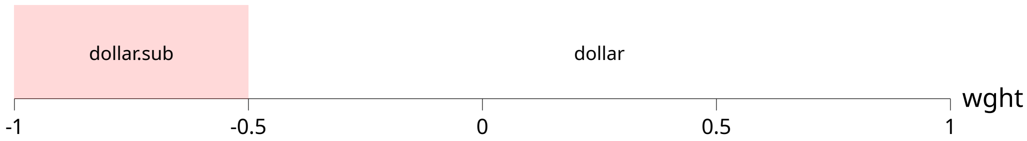
(The July 21st version of this document presented the wght/opsz example with the opsz axis in the opposite direction. This version reverses the direction of that axis by changing the labels, so that the example reflects how the two axes are actually used.)

1 Introduction

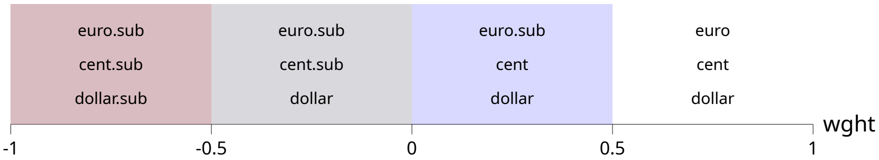
This is a quick discussion of two potential problems with the current OpenType condition set specification, along with possible solutions. The first relates to performance and subtable sizes when the total number of condition sets used across multiple GSUB or GPOS features gets large. The second has to do with a relevant case that isn't handled. I start with some background on single-table condition cases.

2 Background: The single feature case

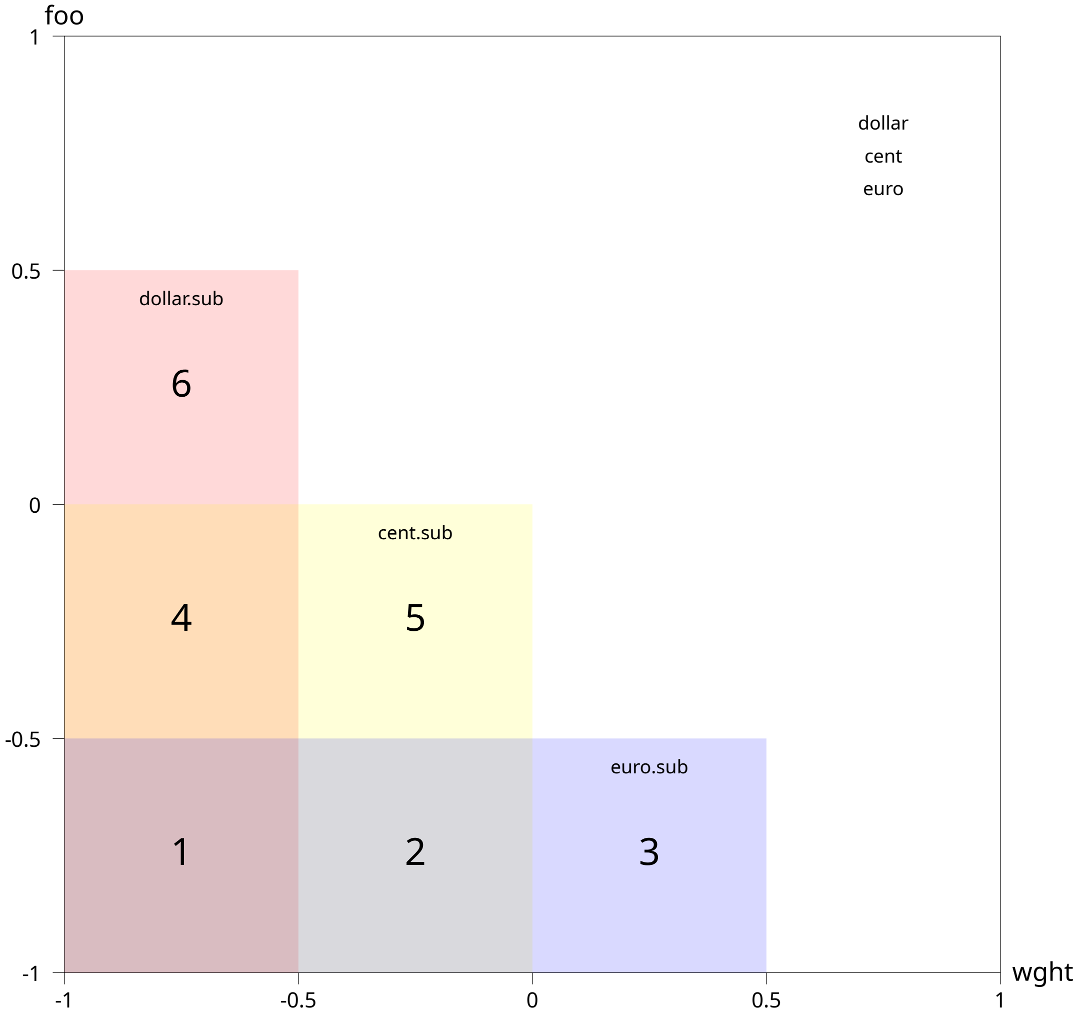
If you have one relevant axis and one substitution, things are very simple. For example you want to use `rvrn` to substitute a double-slash dollar sign at normalized `wght` -.5, with a single-slash dollar sign used elsewhere, you'll wind up with one feature variation record using the single condition -1 <= `wght` <= -0.5 to override the default feature subtable containing the single-slash dollar sign.



Add additional substitutions, all still on a single relevant axis, and things stay simple: the number of FeatureVariation records needed is the number of substitutions needed. So if the `cent` glyph needs a substitution at `wght` 0 and the `euro` glyph needs one at `wght` 0.5, you just need three FeatureVariation records in addition to the base feature subtable. Each new substitution adds a new region.



Things get messier with two axes. Assume a second axis `foo` with these three substitutions: dollar at `wght` -.5, `foo` .5; cent at `wght` 0, `foo` 0; and euro at `wght` .5, `foo` -.5. These add 6 regions in addition to the feature table, for a total of seven combinations. (This would be worse if there was more than one substitution point per axis.)



Broadly speaking there are two ways of encoding these regions. One might be called "geometric", in which each region is distinct. This involves more conditons but smaller condition sets.

```
1)  -1    <= wght <=  -0.5 , -1    <= foo <= -0.5 : dollar.sub , cent.sub , euro.sub
2)  -0.5+ <= wght <=   0   , -1    <= foo <= -0.5 : dollar     , cent.sub , euro.sub
3)  -1    <= wght <= -.5   , -0.5+ <= foo <=  0   : dollar.sub , cent.sub , euro
4)  -0.5+ <= wght <=   0   , -0.5+ <= foo <=  0:  : dollar     , cent.sub , euro
5)   0+   <= wght <=   0.5 , -1    <= foo <= -0.5 : dollar     , cent     , euro.sub
6)  -1    <= wght <=  -0.5 ,  0+   <= foo <=  0.5 : dollar.sub , cent     , euro

Default: dollar, cent, euro
```

The other might be called "logical". This involves fewer conditions but larger condition sets.

```
 D => -1 <= wght <= -0.5 & -1 <= foo <=  0.5
 C => -1 <= wght <=  0   & -1 <= foo <=  0
 E => -1 <= wght <=  0.5 & -1 <= foo <= -0.5
```

```
1)  D & C & E : dollar.sub , cent.sub , euro.sub
2)  C & E     : dollar     , cent.sub , euro.sub
3)  E         : dollar     , cent     , euro.sub
4)  D & C     : dollar.sub , cent.sub , euro
5)  C         : dollar     , cent.sub , euro
6)  D         : dollar.sub , cent     , euro

Default: dollar, cent, euro
```

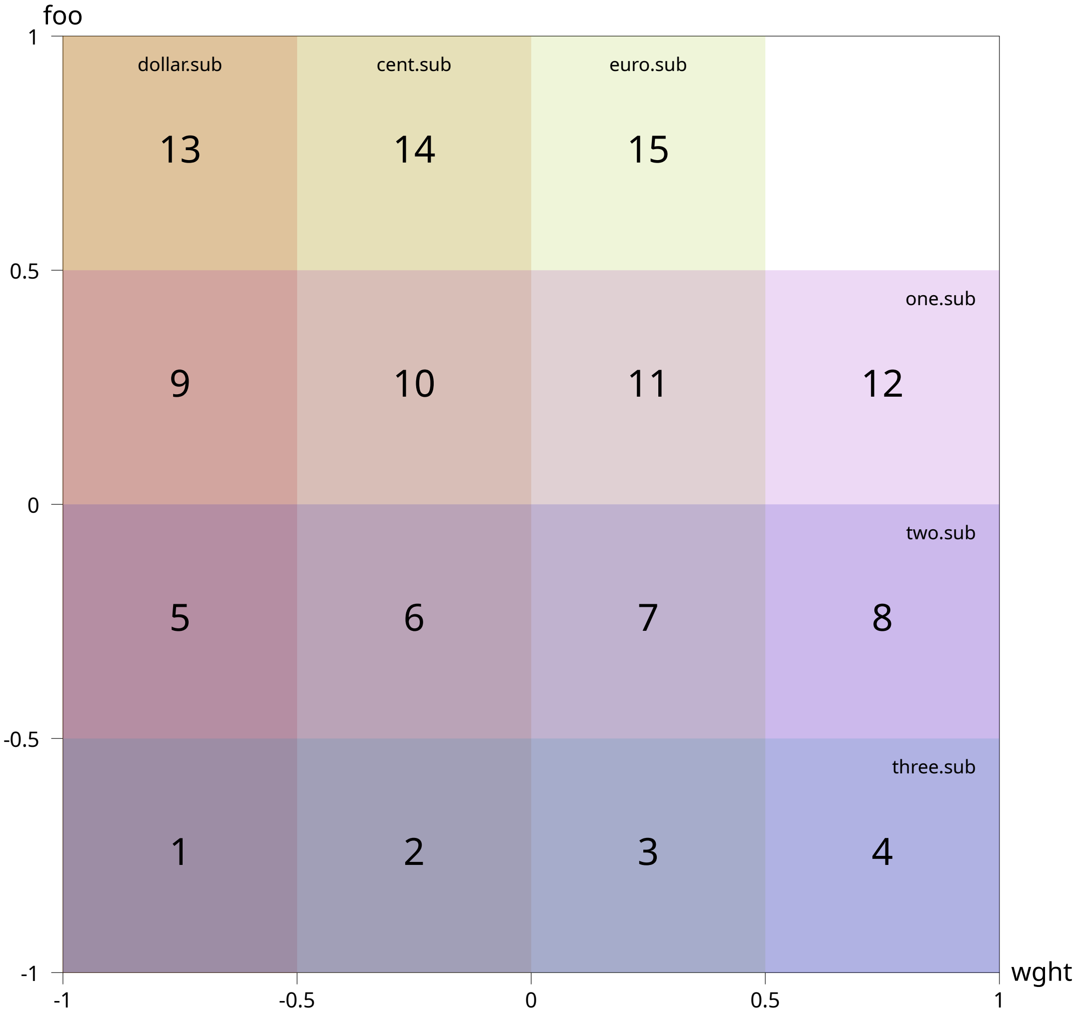
The logical approach works because the search through feature variation records stops the full condition set is met. This means the list can start with a conjunction of all glyph-specific regions and then followed by less and less specific conjunctions. In effect, the more specific conjunctions earlier in the list mask regions of the less specific, later entries.

This need to specify each region one way or another is an inherent part of the feature variations mechanism. It may put practical limits on the number of separate substitutions in a given feature, but avoiding that problem would require an entirely different approach.

3 Problem one: Feature interdependence with substitution

Now suppose that you have a feature with three substitutions on one axis, as well as a different feature with three entirely unrelated substitutions on a different axis. For example, dollar changes at `wght` -.5, cent at `wght` 0, and euro at `wght` .5, while one changes at `foo` -.5, two at `foo` 0, and three at `foo` .5.

Although these substitutions do not seem to be related in the abstract, and will probably not appear to be related when encoded in a feature file, the feature compiler must treat them as related when building the GSUB feature variation subtable in its present form. This is because there is only one unified list of feature variation records per table (GSUB or GPOS). So the above pattern of substitution will not result in 6 regions plus the default (3 for `wght`, 3 for `foo`), but 15.



With a logical encoding those would be (with redundant conditions omitted):

```
D => -1 <= wght <= -0.5
C => -1 <= wght <=  0
E => -1 <= wght <=  0.5
1 => -1 <= foo  <= -0.5
2 => -1 <= foo  <=  0
3 => -1 <= foo  <=  0.5

 1)  D & 1 : dollar.sub , cent.sub , euro.sub , one.sub , two.sub , three.sub
 2)  C & 1 : dollar     , cent.sub , euro.sub , one.sub , two.sub , three.sub
 3)  E & 1 : dollar     , cent     , euro.sub , one.sub , two.sub , three.sub
 4)      1 : dollar     , cent     , euro     , one.sub , two.sub , three.sub
 5)  D & 2 : dollar.sub , cent.sub , euro.sub , one     , two.sub , three.sub
 6)  C & 2 : dollar     , cent.sub , euro.sub , one     , two.sub , three.sub
 7)  E & 2 : dollar     , cent     , euro.sub , one     , two.sub , three.sub
 8)      2 : dollar     , cent     , euro     , one     , two.sub , three.sub
 9)  D & 3 : dollar.sub , cent.sub , euro.sub , one     , two     , three.sub
10)  C & 3 : dollar     , cent.sub , euro.sub , one     , two     , three.sub
```

```
    11)  E & 3 : dollar     , cent     , euro.sub , one     , two     , three.sub
    12)      3 : dollar     , cent     , euro     , one     , two     , three.sub
    13)  D     : dollar.sub , cent.sub , euro.sub , one     , two     , three
    14)  C     : dollar     , cent.sub , euro.sub , one     , two     , three
    15)  E     : dollar     , cent     , euro.sub , one     , two     , three

    def   : dollar     , cent     , euro     , one     , two     , three
```

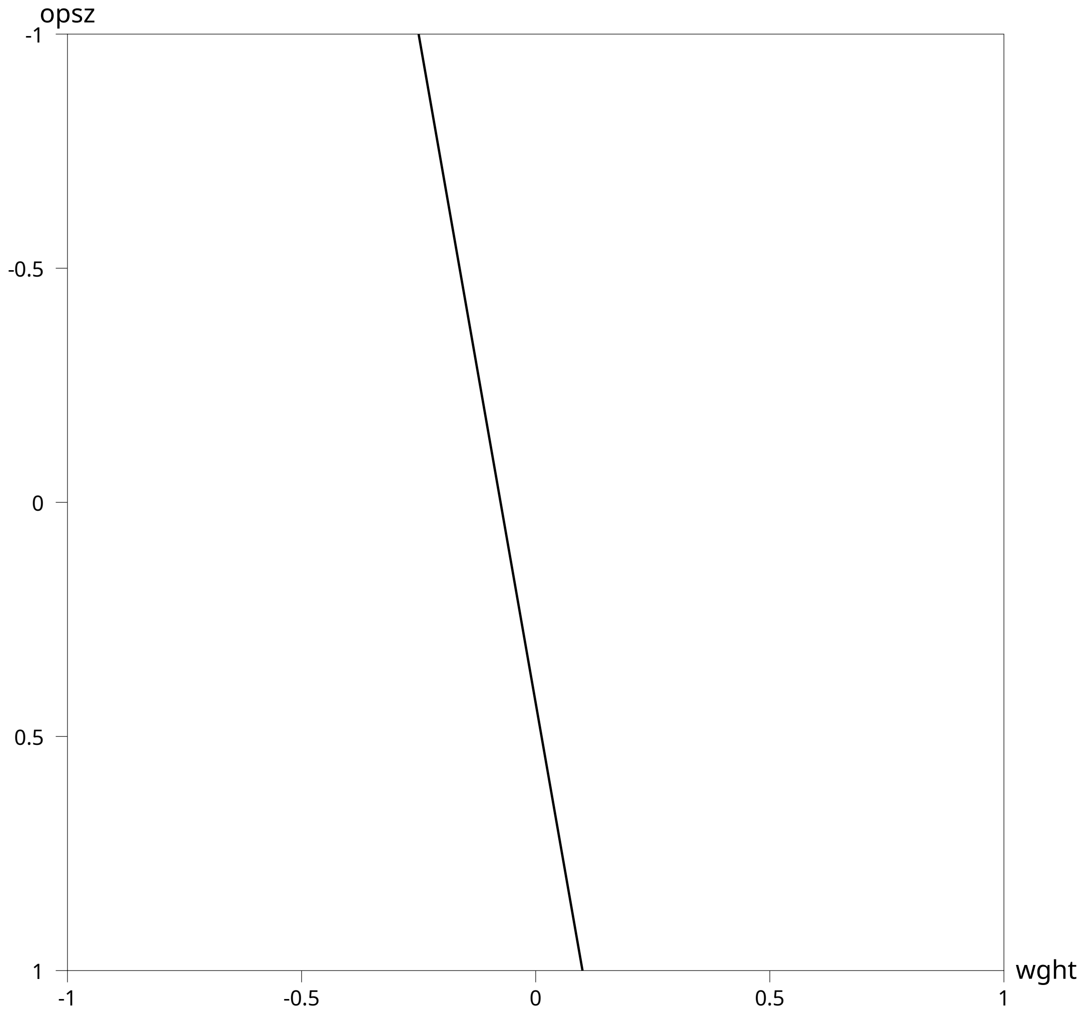
More generally, this means that whatever features use this table, the compiler must carve up the geometry across all of them. Therefore the scaling problem is just not within a feature but across all features.

This seems like a flaw in the current specification, especially because it is *not* an inherent part of the mechanism. I'll suggest one approach to fixing it below. However, some people might wonder whether we'll ever see more than a few regions in practice. With that in mind, let's move on to problem two.

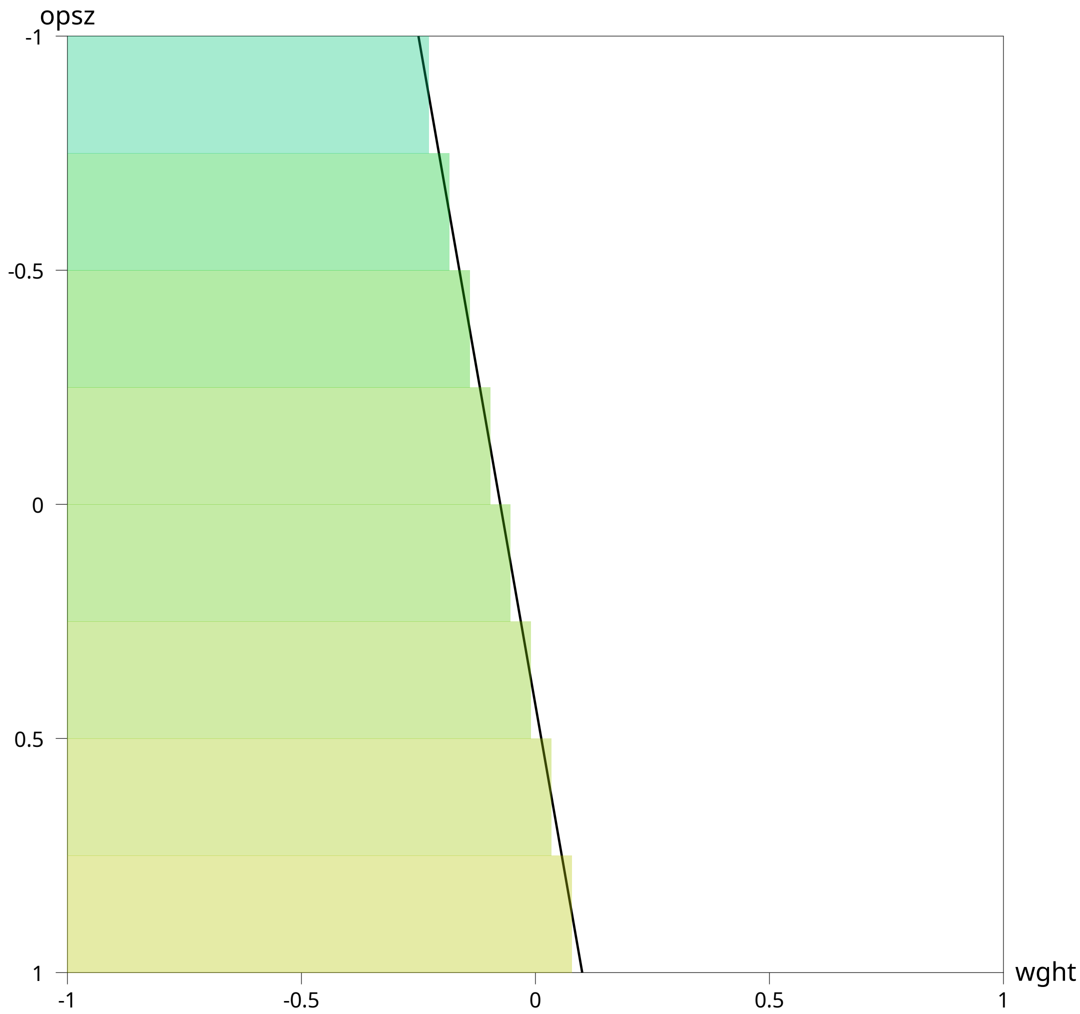
4 Problem two: Substitutions with interdependent axes

Consider the archetypal case of substitution: A variable font has two glyphs for the dollar sign, one with two vertical strokes and another with just one stroke. The designer wants to switch between the glyphs when they judge that the strokes are too thick to leave room for each other. In the usual examples this decision is tied to the `wgwt` axis.

However, the *thickness* of a stroke is not necessarily just a function of one axis. Indeed, the `opsz` axis, which is registered and already used in some variable fonts, also changes the thickness of strokes, with strokes getting somewhat thinner as the axis increases. If a designer's decision about when to substitute is based on thickness, their preference across both axes might look something like this:



Unfortunately this is impossible to express *directly* with the currently available mechanisms. The best you can do is a stepwise approximation, perhaps something like this:



Therefore, even for what isn't all that good an approximation, we now have eight regions plus a default just for one glyph across two axes. If a different glyph needs similar treatment along a different line on the same combination of axes, we can use the same regimentation but will then wind up with 16 regions plus a default. And so on.

Given that such a simple case requires a significant number of regions to handle the substitution of a single glyph, I think we would be wise to fix at least *one* of these problems.

5 Proposed fix for interdependent axis substitution

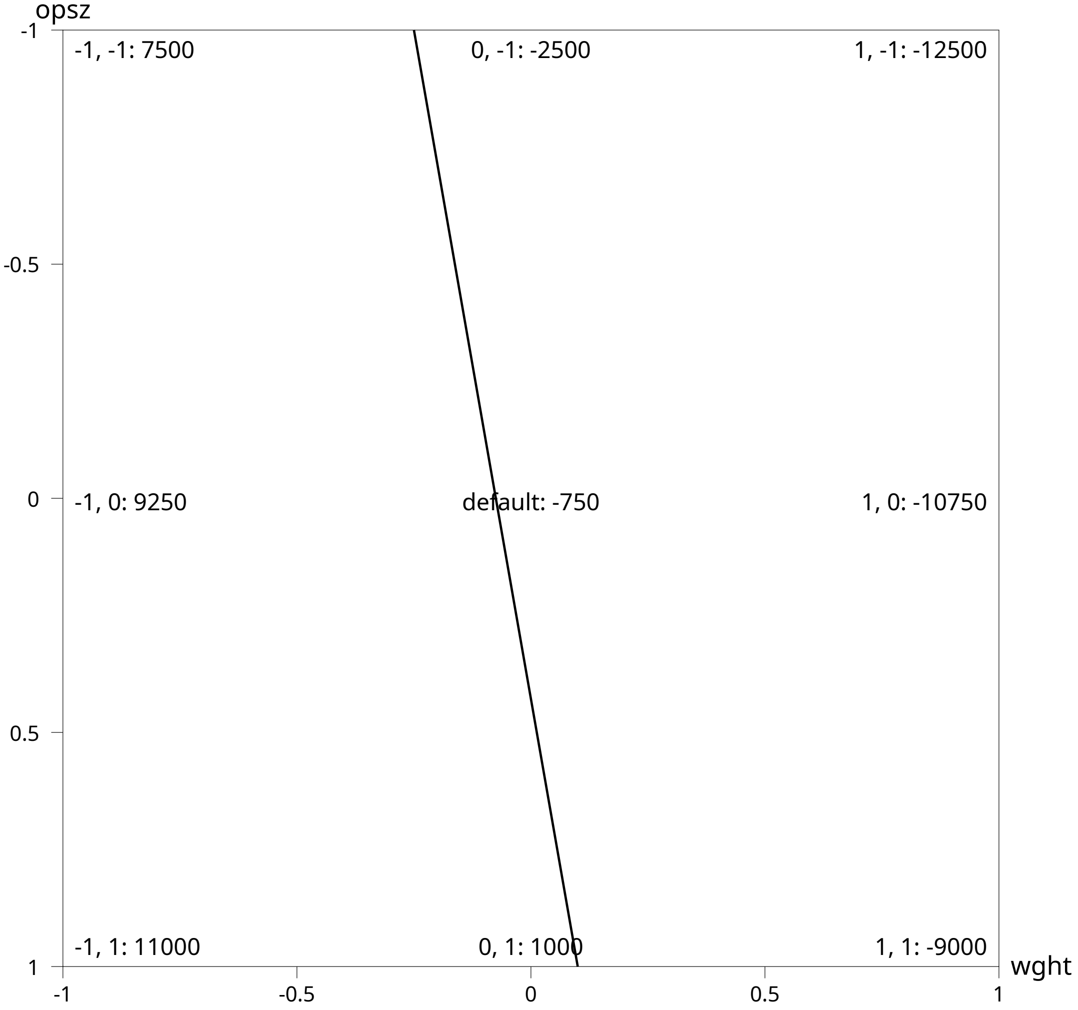
I'm sure there are many novel means of addressing the interdependent axis substitution problem, but it seems easiest to choose the *least* novel. That is, rather than having to invent a bunch of new machinery it seems preferable to use something already available. And in this case the easiest option is to use a normal interpolated value, just like those already used for point locations in glyph outline data or kerning values in GPOS.

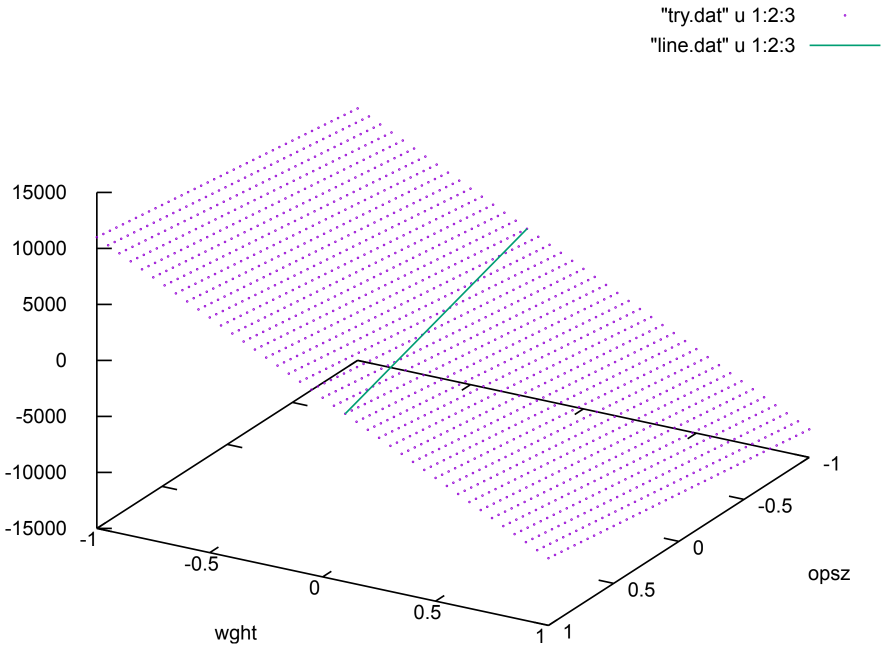
Accordingly, suppose that we were to add Condition Table Format 2: "Condition Value":

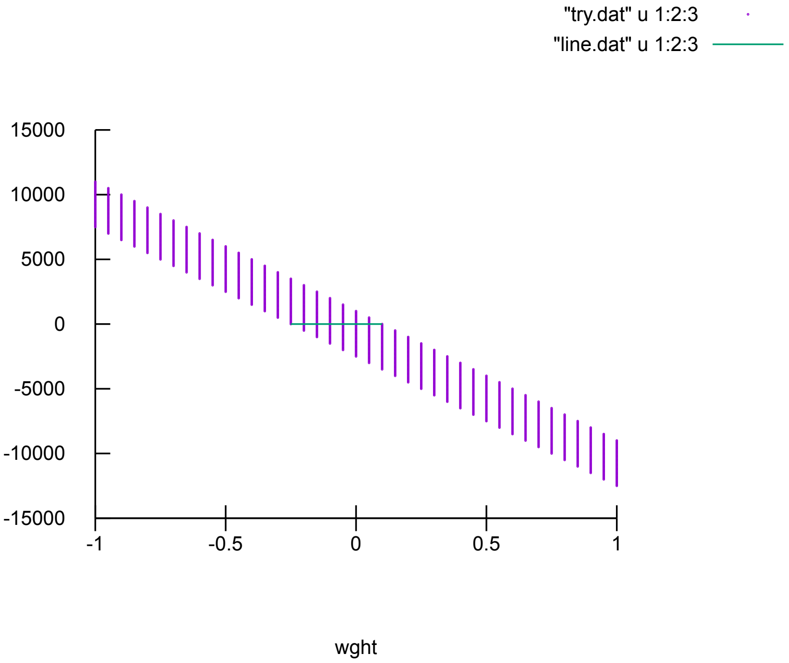
```
uint16    format               Format = 2
int16     default              Value at default location
uint16    deltaSetOuterIndex
uint16    deltaSetInnerIndex
```

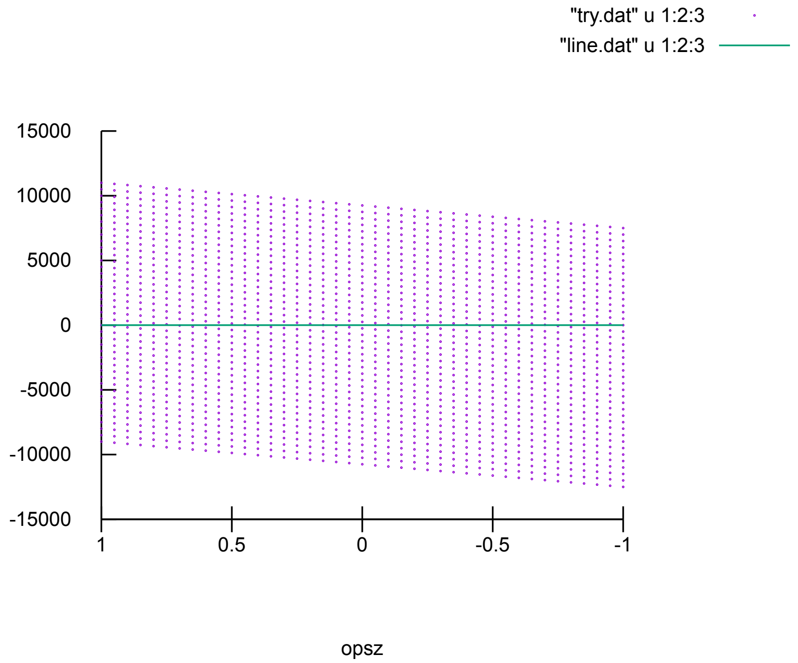
This subtable specifies a varying 16 bit integer by way of its default and a delta set selected with the Outer and Inner Indexes just as in a VariationIndex table. This will be the first case in which an ItemVariationStore is referenced from GSUB, but references in GPOS are already to the IVS in GDEF, so there is little reason GSUB can't also make use of it.

The way this condition works is what you would expect: It evaluates to true when the value is positive and false when it is 0 or negative. The font engineer making use of the condition value is then responsible for placing the "zero line" where the designer needs it.




"try.dat" u 1:2:3
"line.dat" u 1:2:3
15000
10000
5000
0
-5000
-10000
-15000
-1
-0.5
0
0.5
1
wght
1
0.5
0
-0.5
-1
opsz


"try.dat" u 1:2:3
"line.dat" u 1:2:3
15000
10000
5000
0
-5000
-10000
-15000
-1
-0.5
0
0.5
1
wght



As a practical matter a condition value can't directly participate in the geometric style of region partitioning discussed above. However, they work fine with logical partitioning, and do so regardless of which system is being used for other (format 1) conditions. (That is, you can still break down range-based conditions geometrically and then mix those logically with a condition value as needed.) Therefore, while some compilers might need a bit of adjustment it should be possible to mix the two kinds of conditions as needed.

Some drafts of the avar 2 proposal note a need for a better condition mechanism. I am not sure whether condition values can address all of that need. However, I will note that while with traditional axes they can only define straight lines in design space, with HOI they could presumably define curved lines, so at least in broad strokes the mechanism appears to be "HOI ready".

6 Proposed fix for feature interdependence

This is more of a sketch than a finished proposal, as there are a lot of ways to modify the actual subtables, adjust the versions, etc.

Conceptually, all that is needed to solve the problem is advance knowledge of *which* features are encoded among the feature variation records. This list could be encoded by sorted tag in some new subtable.

Then, as the Feature Variation records are examined in order, instead of stopping at the first match the search stops when a record corresponding to each feature in the initial list is found. That way the entries for different layout features can be interspersed without interfering with one another. If the feature list is present you use the new search convention, if not you use the old one.