

Venn diagrams

Technical details and regression checks

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20th June, 2026

- Try CR for weight=0
- Plot faces for Chow-Ruskey
- General set membership
- implement not showing dark matter eg Fig 1
- AWFE-book like figures
- likesquares argument for triangles
- central dark matter
- Comment on triangles
- Comment on AWFE
- text boxes
- use grob objects/printing properly
- cope with missing data including missing zero intersection;
- discuss Chow-Ruskey zero=nonsimple

1 Venn objects

```
> if ("package:Vennerable" %in% search()) detach("package:Vennerable")
> library(Vennerable)
> library(grid)

> Vcombo <- Venn(SetNames=c("Female", "Visible Minority", "CS Major"),
+               Weight= c(0, 4148, 409, 604, 543, 67, 183, 146)
+ )
> setList <- strsplit(month.name, split="")
> names(setList) <- month.name
> VN3 <- VennFromSets( setList[1:3])
> V2 <- VN3[,c("January", "February"),]
```

```

> V4 <- VennFromSets( setList[1:4])
> V4f <- V4
> V4f@IndicatorWeight[, ".Weight"] <- 1

> setList <- strsplit(month.name, split="")
> names(setList) <- month.name
> VN3 <- VennFromSets( setList[1:3])
> V2 <- VN3[, c("January", "February"), ]

> V3.big <- Venn(SetNames=month.name[1:3], Weight=2^(1:3))
> V2.big <- V3.big[, c(1:2)]

> Vempty <- VennFromSets( setList[c(4, 5, 7)])
> Vempty2 <- VennFromSets( setList[c(4, 5, 11)])
> Vempty3 <- VennFromSets( setList[c(4, 5, 6)])
>

```

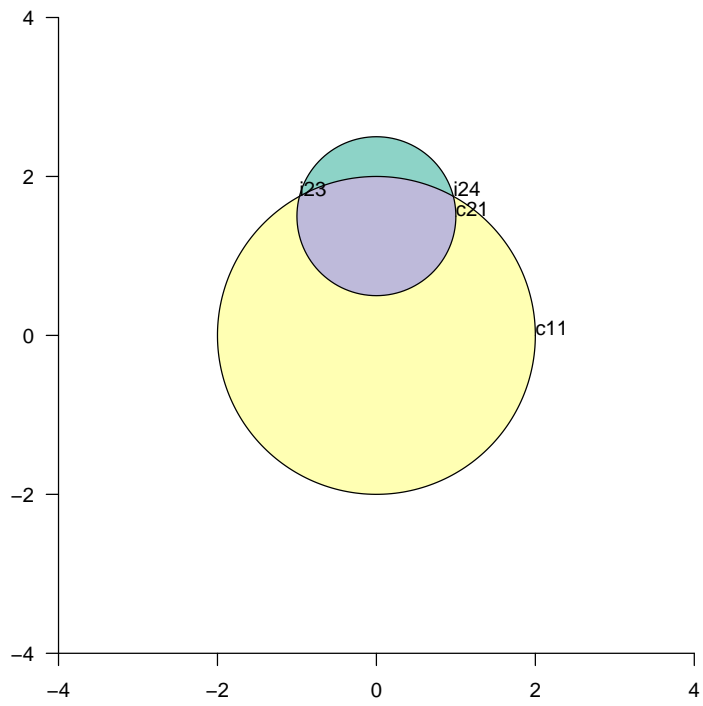
2 The VennDrawing object

This is created from a TissueDrawing object and a Venn object

```

> centre.xy <- c(0, 0)
> VDC1 <- Vennerable:::newTissueFromCircle(centre.xy, radius=2, Set=1);
> VDC2 <- Vennerable:::newTissueFromCircle(centre.xy+c(0, 1.5), radius=1, Set=2)
> TM <- Vennerable:::addSetToDrawing (drawing1=VDC1, drawing2=VDC2, set2Name="Set2")
> VD2 <- new("VennDrawing", TM, V2)
>

```



3 Two circles

3.1 Two circles

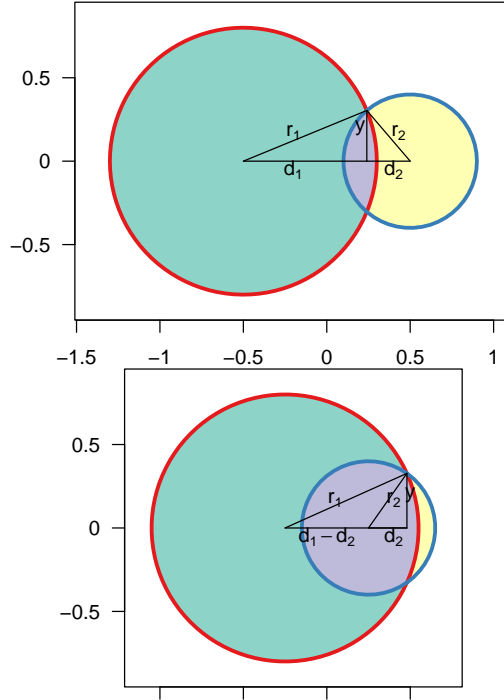


Figure 1: Geometry of two overlapping circles

There is an intersection if $|r_1 - r_2| < d < r_1 + r_2$. If so and $d < \max(r_1, r_2)$ the centre of the smaller circle is in the interior of the larger. Either way we have the relationships

$$\begin{aligned} d_1^2 + y^2 &= r_1^2 \\ d_2^2 + y^2 &= r_2^2 \end{aligned}$$

If $\max(r_1, r_2) < d < r_1 + r_2$ then $d = d_1 + d_2$; if $|r_1 - r_2| < d < \max(r_1, r_2)$ then $d = |d_1 - d_2|$.

We rely on the relationships

$$\begin{aligned} d_1 &= (d^2 - r_2^2 + r_1^2)/(2d) \\ d_2 &= |d - d_1| \\ y &= \frac{1}{2d} \sqrt{4d^2 r_1^2 - (d^2 - r_2^2 + r_1^2)^2} \\ &= \sqrt{r_1^2 - d_1^2} \end{aligned}$$

3.2 Weighted 2-set Venn diagrams for 2 Sets

3.2.1 Circles

It is always possible to get an exactly area-weighted solution for two circles as shown in Figure 2.

```
      00      11      10      01
475.9979 271.9995  67.9992 135.9992
```

```
[1] "Area check passed"
```

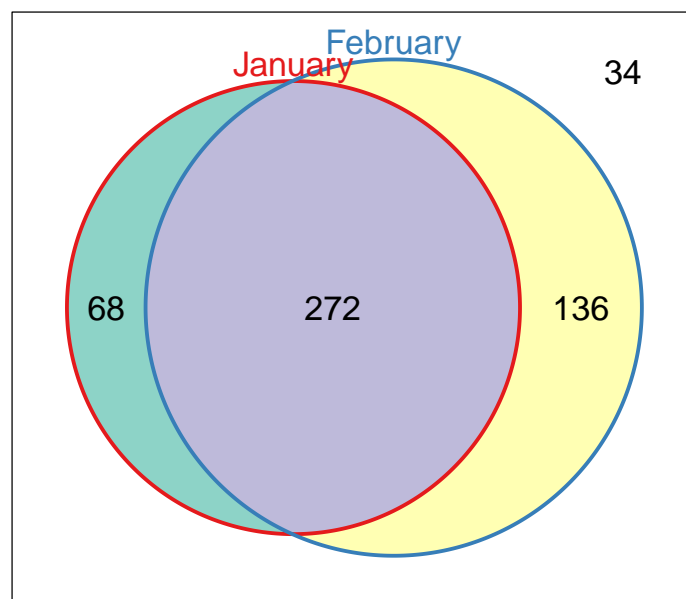


Figure 2: Weighted 2d Venn

3.3 2-set Euler diagrams

3.3.1 Circles

```
      00      11      10      01
7.1339724 3.8633868 0.1352894 3.1352961
```

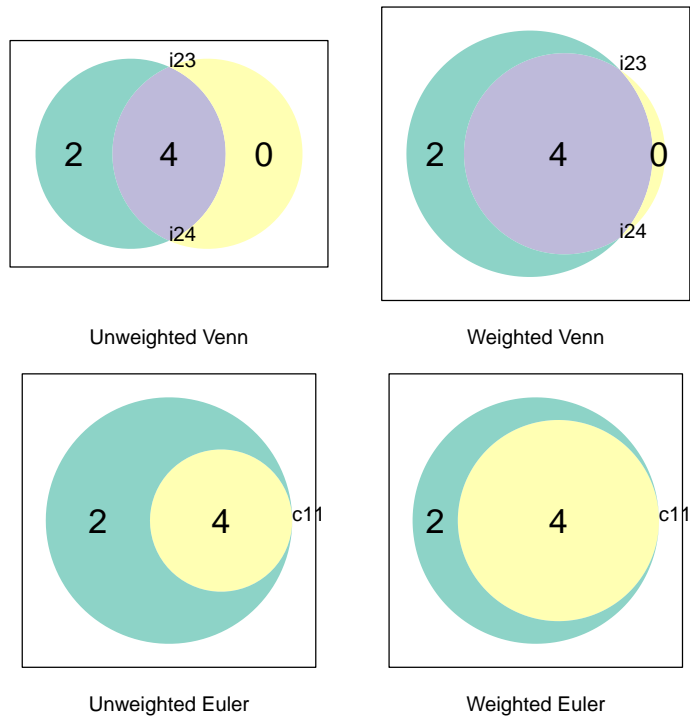
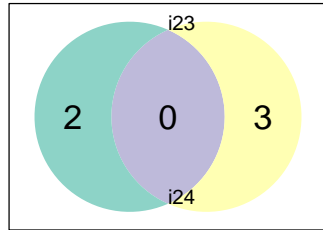
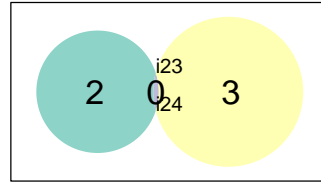


Figure 3: Effect of the Euler and doWeights flags.



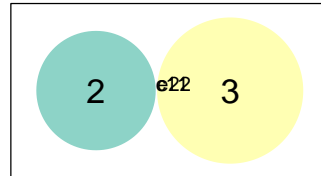
Unweighted Venn



Weighted Venn

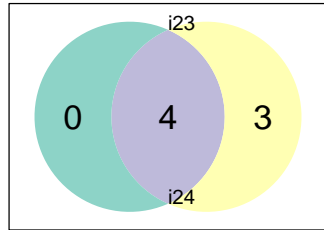


Unweighted Euler

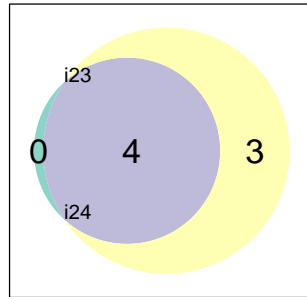


Weighted Euler

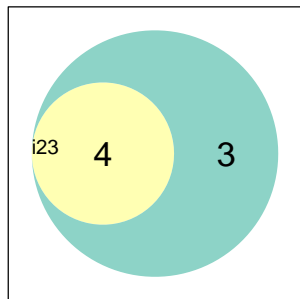
Figure 4: As before for a different set of weights



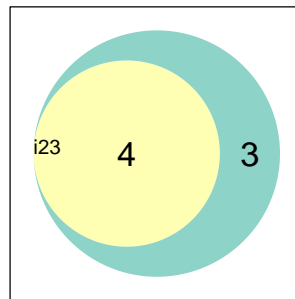
Unweighted Venn



Weighted Venn



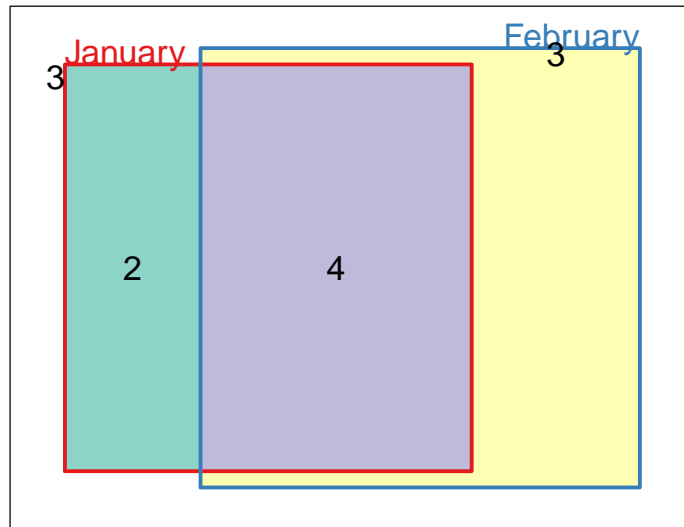
Unweighted Euler



Weighted Euler

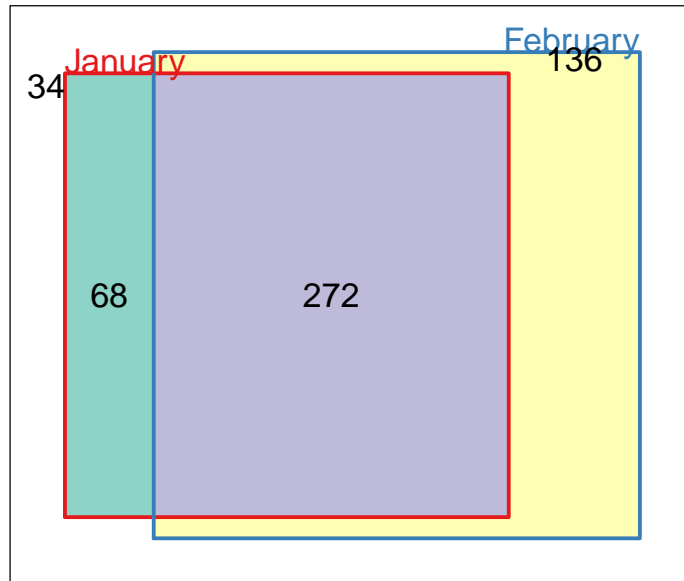
Figure 5: As before for a different set of weights

4 Two squares

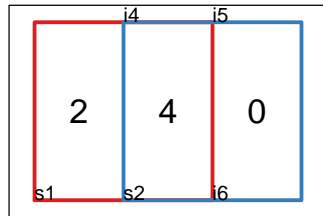


4.0.1 Weights

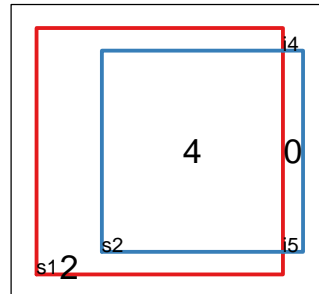
00 11 10 01
476 272 68 136



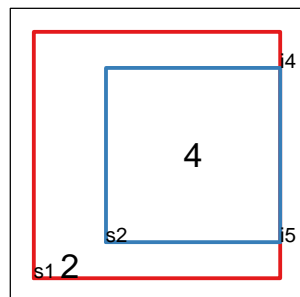
4.0.2 Squares



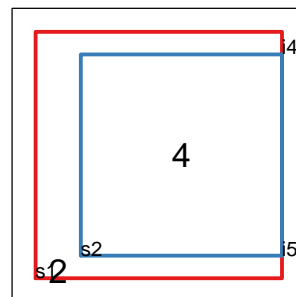
Unweighted Venn



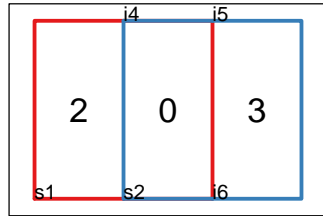
Weighted Venn



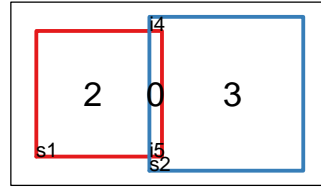
Unweighted Euler



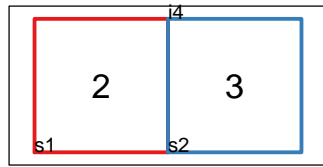
Weighted Euler



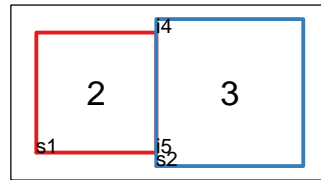
Unweighted Venn



Weighted Venn

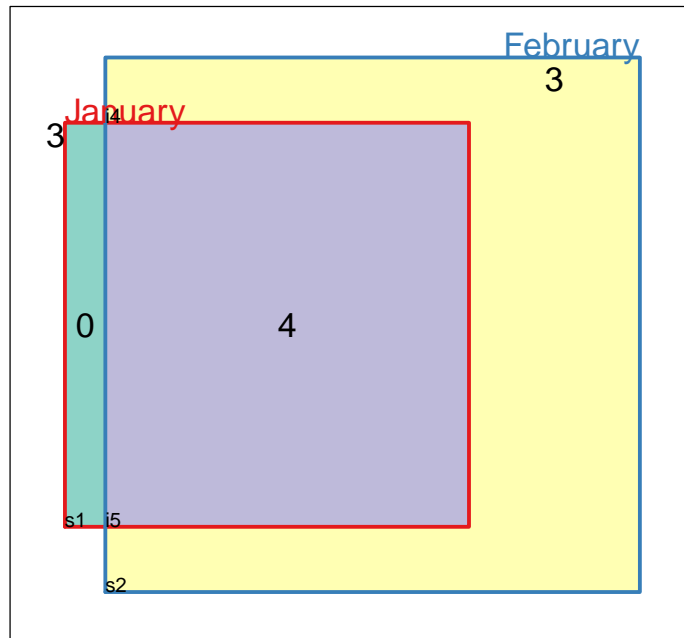


Unweighted Euler



Weighted Euler

00 11 10 01
7.4 3.6 0.4 3.4



5 Three circles

```
> plot(Vcombo, doWeights=FALSE, show=list(Faces=TRUE))
```

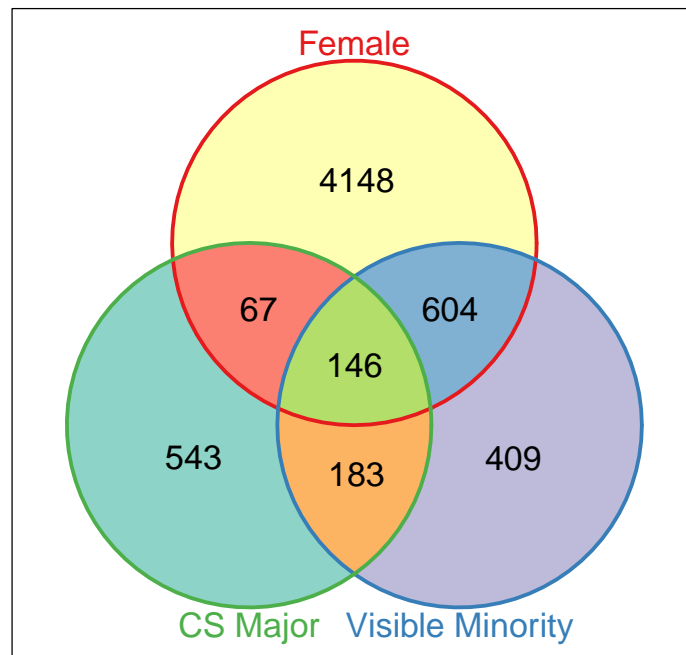


Figure 6: A three-circle Venn diagram

5.0.1 Weights

There is no general way of creating area-proportional 3-circle diagrams. The package makes an attempt to produce approximate ones.

```

000      001      101      100      111      110      011
6094.83358 537.83535 72.16413 4142.83542 140.83530 609.16384 188.16391
010
403.83563

```

```
[1] "Area check passed"
```

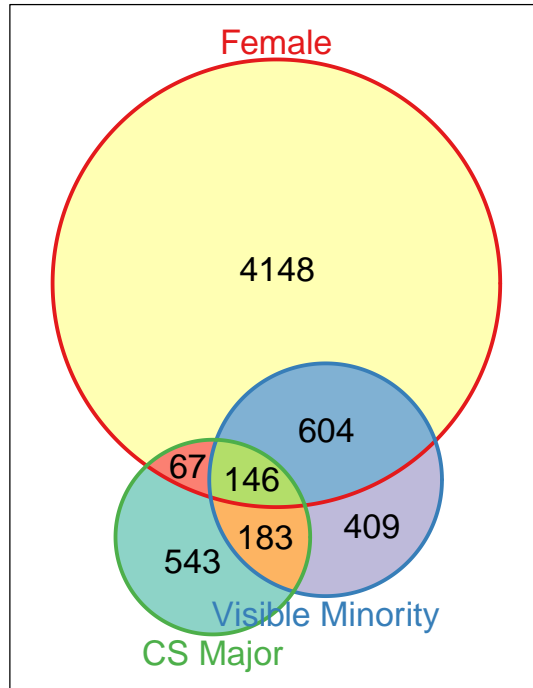


Figure 7: 3D Venn diagram. All of the areas are correct to within 10%

6 Three Triangles

The triangular Venn diagram on 3-sets lends itself nicely to an area-proportional drawing under some constraints on the weights

[1] "Area check passed"

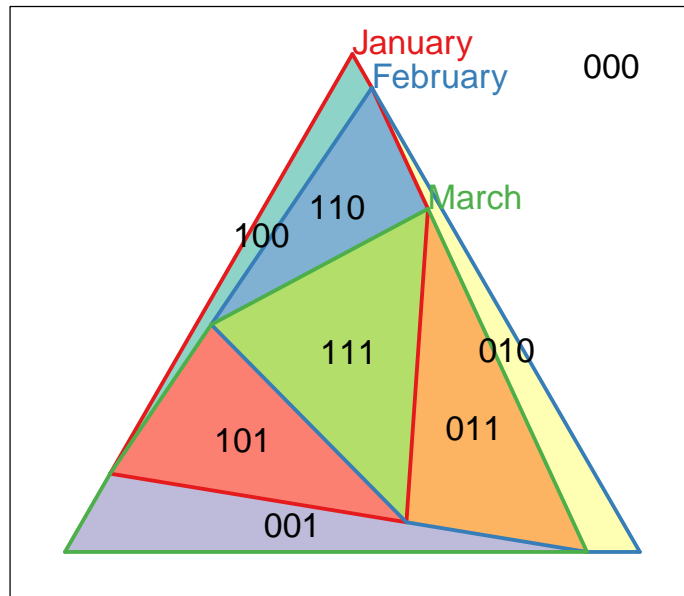


Figure 8: Triangular Venn with external universe

6.1 Triangular Venn diagrams

6.1.1 Triangles

000 100 010 111 110 001
12 2 3 2 2 3

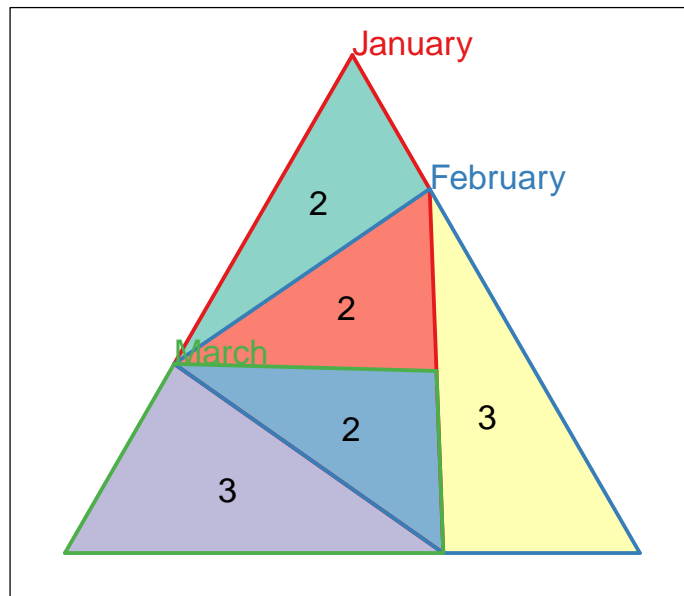
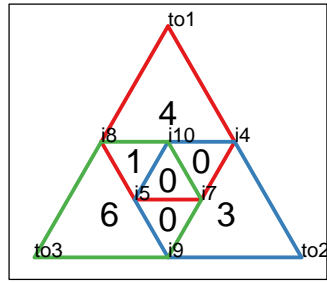
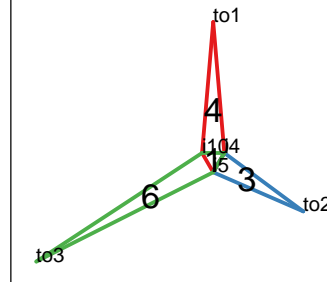


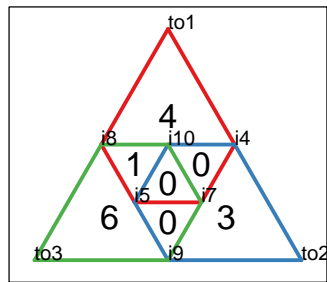
Figure 9: 3d Venn triangular with one empty intersection



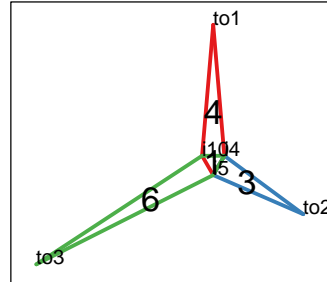
Unweighted Venn



Weighted Venn

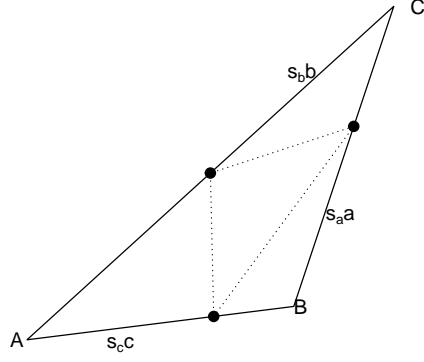


Unweighted Euler



Weighted Euler

Figure 10: 3d Venn triangular with two empty intersection



Given a triangle ABC of area Δ and some nonnegative weights $w_a + w_b + w_c < 1$ we want to set s_c , s_a and s_b so that the areas of each of the apical triangles are Δ -proportional to w_a , w_b and w_c . This means

$$s_c(1-s_b)bc \sin A = 2w_a\Delta \quad (1)$$

$$s_a(1-s_c)ca \sin B = 2w_b\Delta \quad (2)$$

$$s_b(1-s_a)ab \sin C = 2w_c\Delta \quad (3)$$

So

$$s_c(1-s_b) = w_a \quad (4)$$

$$s_a(1-s_c) = w_b \quad (5)$$

$$s_b(1-s_a) = w_c \quad (6)$$

$$s_b = 1 - w_a/s_c \quad (7)$$

$$s_a = w_b/(1-s_c) \quad (8)$$

$$(s_c - w_a)(1 - s_c - w_b) = s_c(1 - s_c)w_c \quad (9)$$

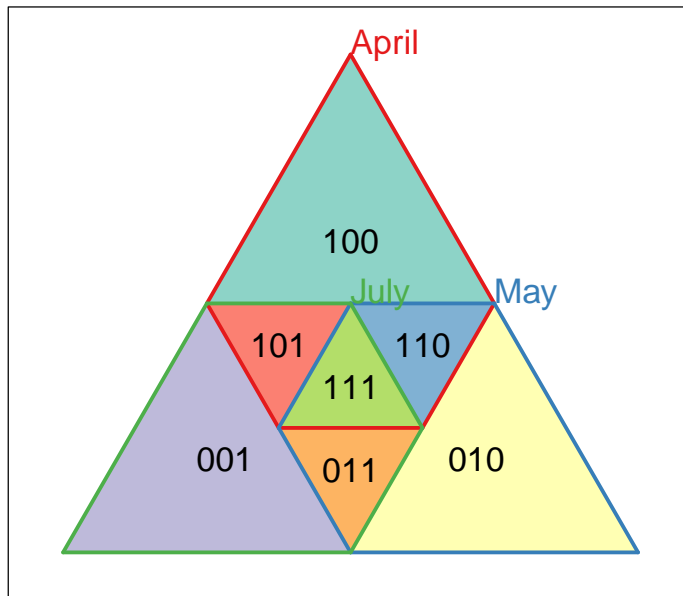
$$s_c^2(1 - w_c) + s_c(w_b + w_c - w_a - 1) + w_a(1 - w_b) = 0 \quad (10)$$

Iff

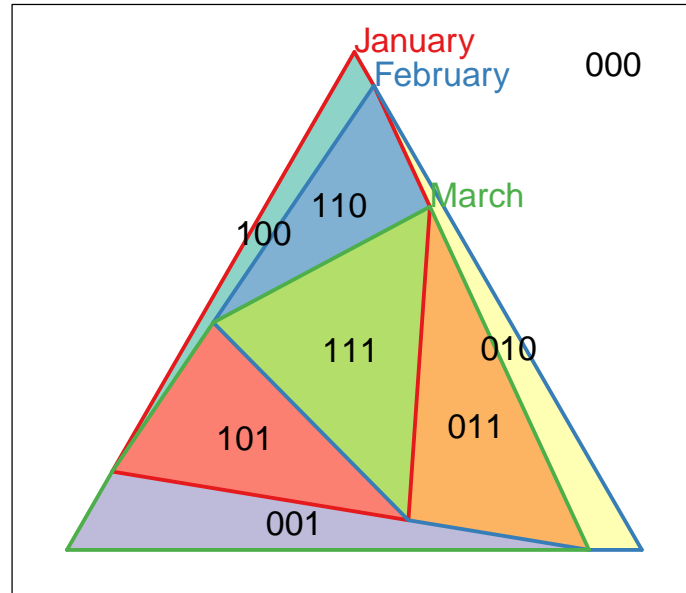
$$4w_a w_b w_c < (1 - (w_a + w_b + w_c))^2 \quad (11)$$

this has two real solutions between w_a and $1 - w_b$.

[1] TRUE



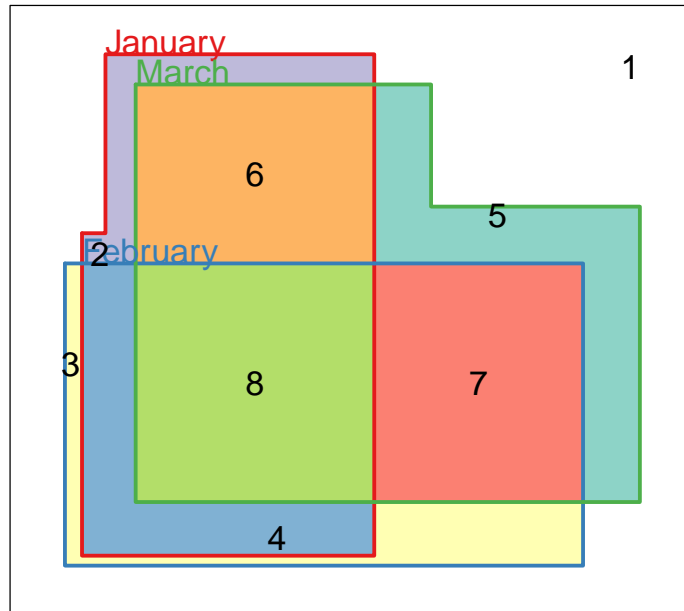
6.2 Three triangles



7 Three Squares

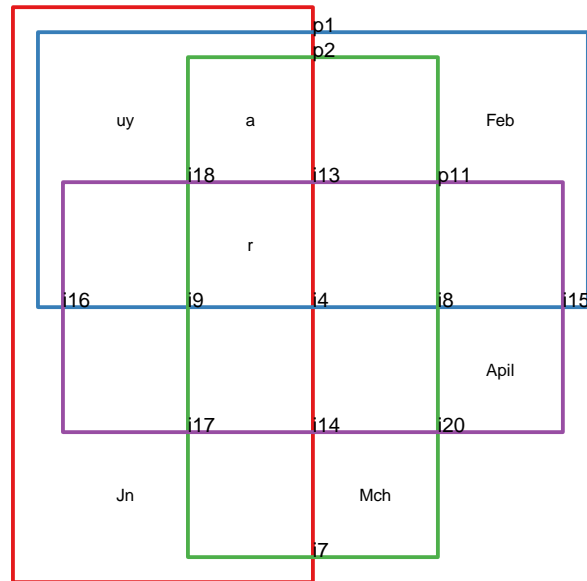
This is a version of the algorithm suggested by Chow Ruskey 2003.

7.1 Three squares



8 Four squares

8.1 Unweighted 4-set Venn diagrams

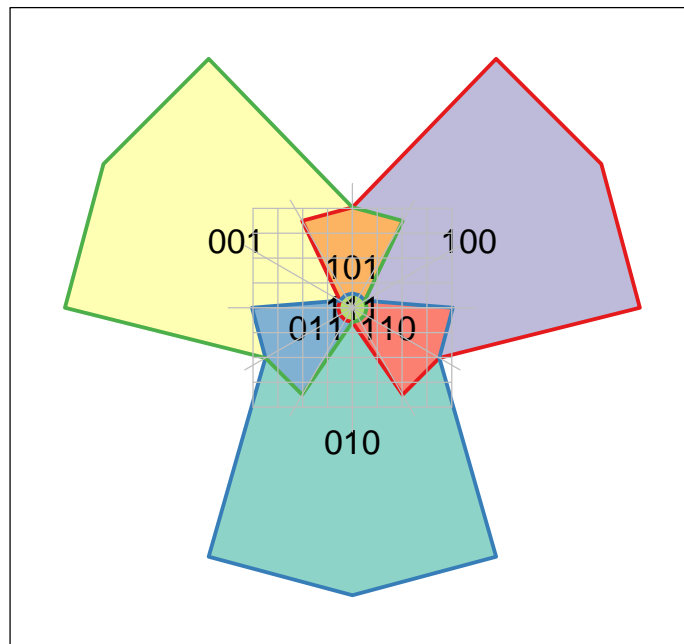


9 Chow-Ruskey

See [2, 1].

9.1 Chow-Ruskey diagrams for 3 sets

[1] "Area check passed"



[1] "Area check passed"

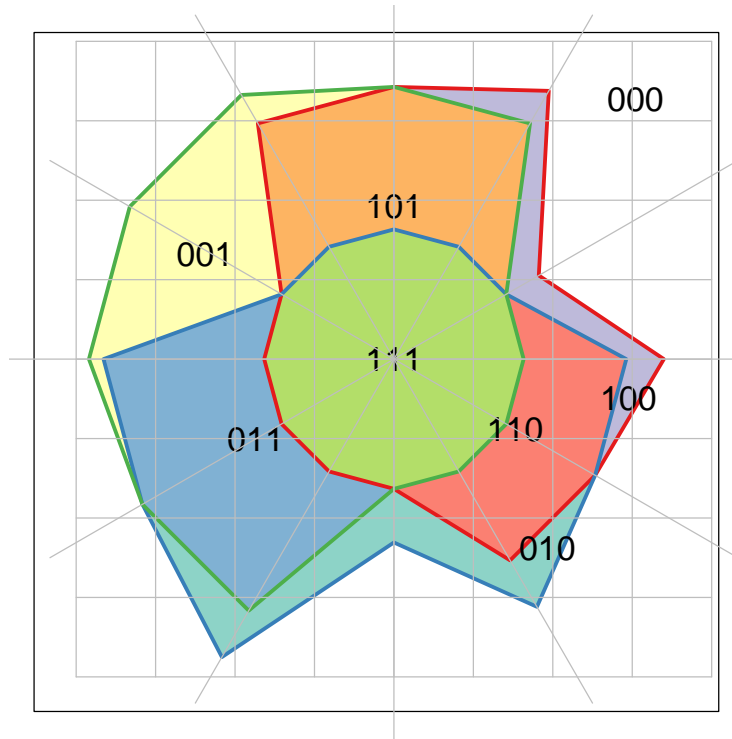


Figure 12: Chow-Ruskey CR3f

[1] "Area check passed"

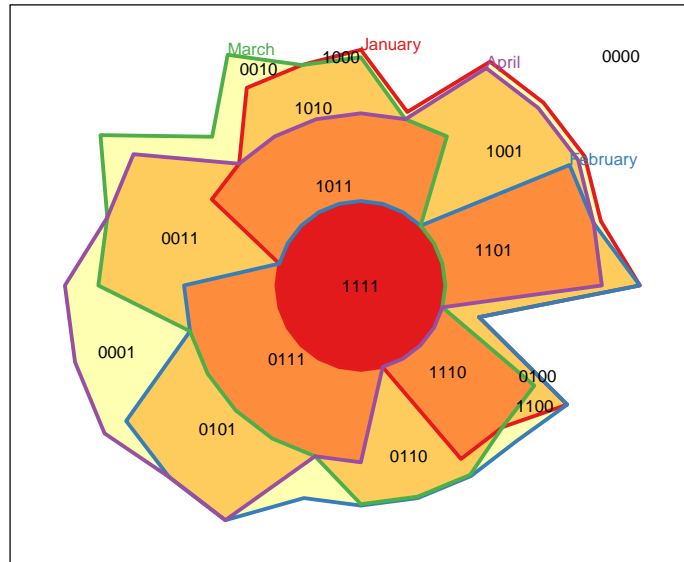


Figure 13: Chow-Ruskey weighted 4-set diagram, produces an error if we try to plot signature face text

[1] "Area check passed"

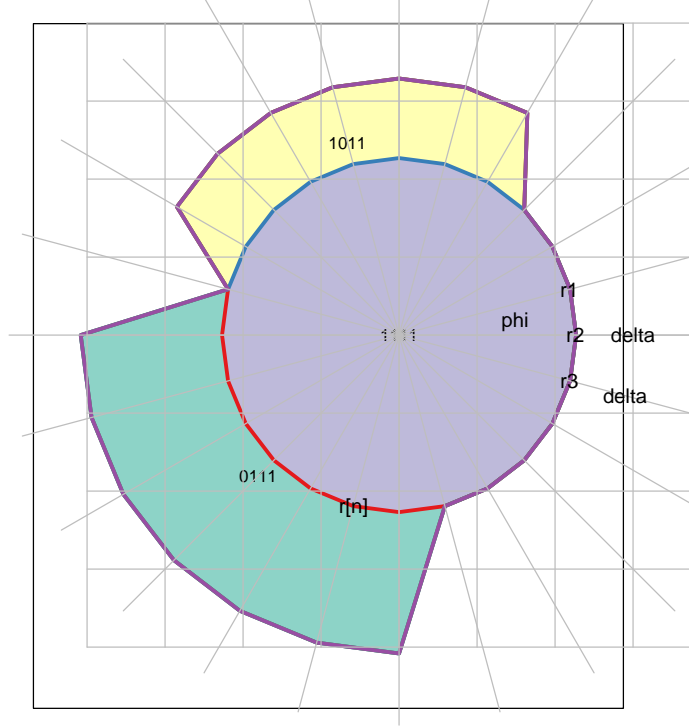


Figure 14: Chow-Ruskey weighted 4-set diagram

The area of the sector $0r_1r_2$ is $\frac{1}{2}r_1r_2\sin\phi$. The area of $0r_1s_2$ is $\frac{1}{2}(r_1(r_2 + \delta)\sin\phi)$ and so the area of $r_1r_2s_2$ is $\frac{1}{2}(r_1\delta\sin\phi)$.

The area of $r_2r_2s_2s_3$ is $\frac{1}{2}[(r_3 + \delta)(r_2 + \delta) - r_3r_2]\sin\phi = \frac{1}{2}[(r_3 + r_2)\delta + \delta^2]\sin\phi$.

The total area of the outer shape is

$$A = \frac{1}{2}(\sin\phi) \left[(r_1 + r_n)\delta + \sum_{k=2}^{n-2} [(r_{k+1} + r_k)\delta + \delta^2] \right] \quad (12)$$

$$= \frac{1}{2}(\sin\phi) \left[(r_1 + r_n)\delta + (n-2)\delta^2 + \delta \sum_{k=2}^{n-2} [(r_{k+1} + r_k)] \right] \quad (13)$$

$$= \frac{1}{2}(\sin\phi) [(r_1 + r_2 + 2r_3 + \dots + 2r_{n-2} + r_{n-1} + r_n)\delta + (n-3)\delta^2] \quad (14)$$

so

$$0 = c_a\delta^2 + c_b\delta + c_c \quad (15)$$

$$c_a = n-3 \quad (16)$$

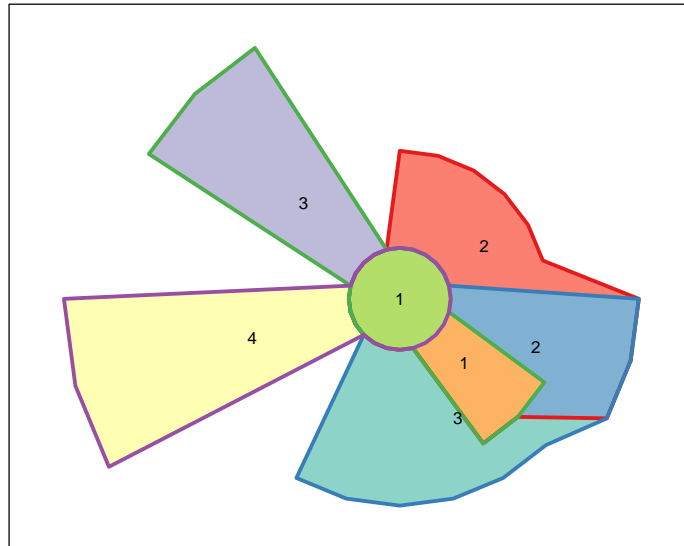
$$c_b = r_1 + r_2 + 2r_3 + \dots + 2r_{n-2} + r_{n-1} + r_n \quad (17)$$

$$c_c = -A/\frac{1}{2}\sin\phi \quad (18)$$

This is implemented in the compute.delta function.

If all the r s are the same then $c_b = [2(n-3) + 4]r = (2n-2)r$.

[1] "Area check passed"



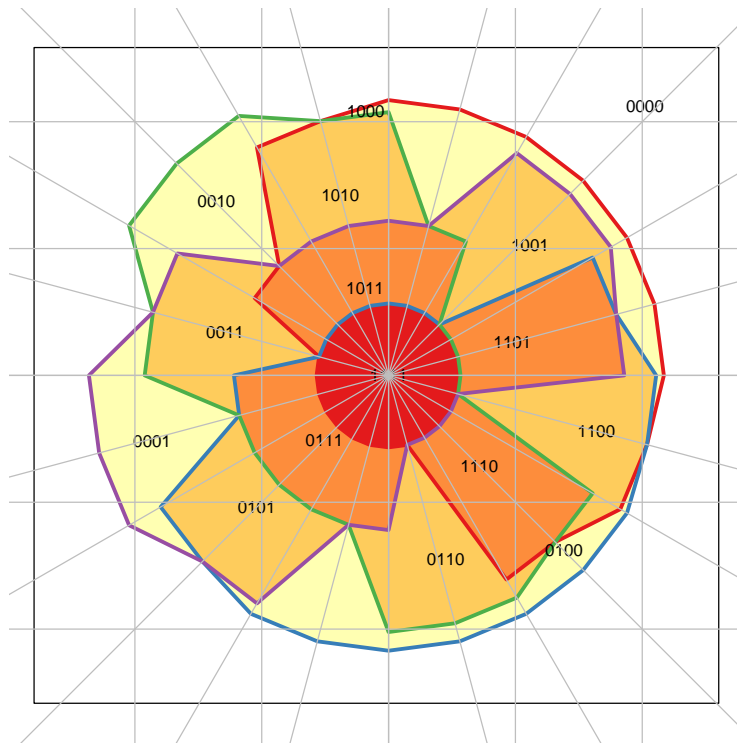


Figure 15: Chow-Ruskey 4

10 Euler diagrams

10.1 3-set Euler diagrams

10.1.1 Other examples of circles

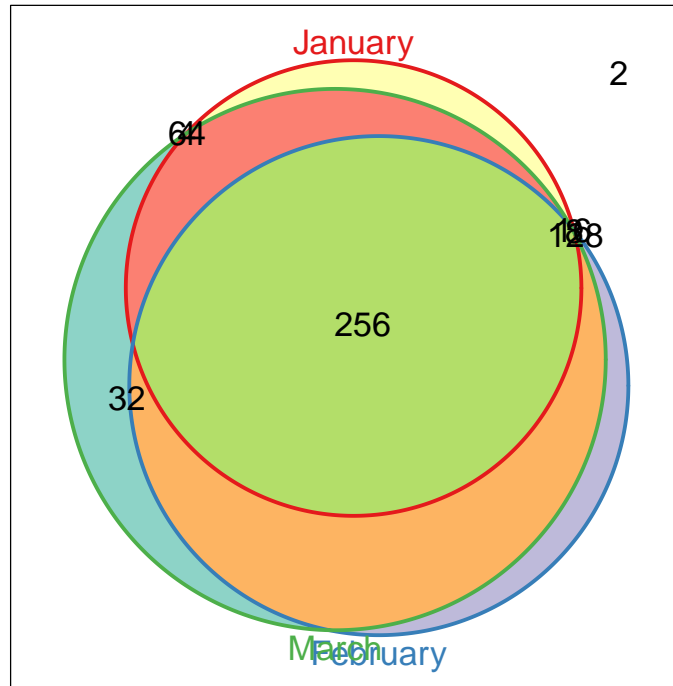


Figure 16: TODO Big weighted 3d Venn fails

11 Error checking

These should fail

```
> print(try(Venn(numberOfSets=3,Weight=1:7)))

[1] "Error in Venn(numberOfSets = 3, Weight = 1:7) : \n Weight length does not match numb
attr(,"class")
[1] "try-error"
attr(,"condition")
<simpleError in Venn(numberOfSets = 3, Weight = 1:7): Weight length does not match number

> print(try(V3[1,]))

[1] "Error in V3[1, ] : Can't subset on rows\n"
attr(,"class")
[1] "try-error"
attr(,"condition")
<simpleError in V3[1, ]: Can't subset on rows>
```

Empty objects work

```
> V0 = Venn()
> (Weights(V0))

named numeric(0)

> VennSetNames(V0)

character(0)
```

12 This document

Author	Jonathan Swinton
Generated on	20 th June, 2026
R version	R version 4.6.0 (2026-04-24)

References

- [1] Stirling Chow and Frank Ruskey. Drawing area-proportional Venn and Euler diagrams. In Giuseppe Liotta, editor, *Graph Drawing*, volume 2912 of *Lecture Notes in Computer Science*, pages 466–477. Springer, 2003.
- [2] Stirling Chow and Frank Ruskey. Towards a general solution to drawing area-proportional Euler diagrams. *Electronic Notes in Theoretical Computer Science*, 134:3–18, 2005.