How to use
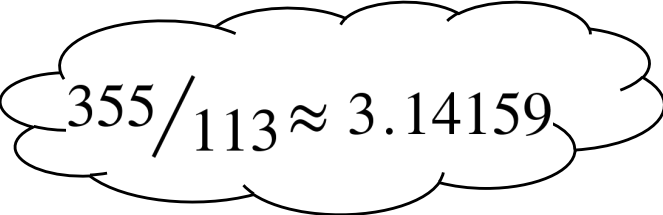# the back calculator program
"denomfind"
for approximated proportions

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Toshiyuki Shimono

Terminology (1/2)

$$355/113 \approx 3.14159$$

- A **fraction** is specified in the form of **numerator** / **denominator** .

- A **proportion** is the decimal value of a fraction. Its approximation is an **approximated proportion**, which would be simply called a proportion herein.

- $\mathbb{N} = \{1,2,3,... \}$: The set of all natural numbers.
- $\mathbb{Z} = \{0 , \pm 1 , \pm 2 , \pm 3 , ..\}$: consists of integers.
- $\mathbb{R} = \{ x \mid -\infty < x < +\infty \}$: all the real numbers.

Terminology (2/2)

- There are many ways to **round** a number :
  - Round half up (most commonly used!)
  - Round up / Round down
  - Round half to even (ISO 31-0 , JIS Z 8401, IEEE 754)
  - Round half to odd
- **TSV** is Tab-Separeted Values (cf. CSV with comma).

Regarding this document :

- Explains
  - how to use the command **denomfind**.
- Not explains
  - the internal design in detail.

"denomfind" is a CLI program.

- CLI = Command Line Interface. Not a GUI.
- "denomfind" is a program of a Perl script.
- You can install :
  - By "cpan" or "cpanm" command.
    - cpanm is recommendable considering the un-installment.
    - **cpanm App::denomfind**
    - **cpanm –U App::denomfind # uninstall**
  - Not only from **metacpan.org** but also from **GitHub**.

Examples 1 — 0.3, 0.33, and 33.3%

```
> denomfind 0.3
denom   fit     0.3
3       1       1/3
4       1       1/4
6.      1       2/6
7       1       2/7
8.      1       2/8
9.      1       3/9
10      1       3/10
11      1       3/11
12      1       3/12~4/12
13      1       4/13
14.     1       4/14
15      1       4/15~5/15
```

```
> denomfind -M0 0.33
denom   fit     0.33
3       1       1/3
40      1       13/40
43      1       14/43
46      1       15/46
49      1       16/49
52      1       17/52
55      1       18/55
58      1       19/58
61      1       20/61
64      1       21/64
67      1       22/67
70      1       23/70
```

```
> denomfind -M0 -D-3% 33.3%
denom   fit     0.333
3       1       1/3-.033%
400     1       133/400+.050%
403     1       134/403+.049%
406     1       135/406+.049%
409     1       136/409+.048%
412     1       137/412+.048%
415     1       138/415+.047%
418     1       139/418+.046%
421     1       140/421+.046%
424     1       141/424+.045%
427     1       142/427+.045%
430     1       143/430+.044%
```

Each fraction is shown on each line.

- "*denom*" means **denominator**.

- 12 *denom*s $\in \mathbb{N}$ are **back calculated**

  with **a feasible numerator** $\in \mathbb{Z}$

  regarding the given proportion is **rounded**.

- Each of *fraction form* is shown in cyan color.

- -D-3% on the most right image specifies
  to show the **gap** to the proportion.

- "*fit*" (red) will be explained in next page.

Regarding the reducible fractions :

- A *denom* with period (.) :
  roughly means the fraction is **reducible**.

- To be more exactly (explained later) :
  the numerators and its corresp. denominators
  all combined are divisible by their GCD > 1.

- "-M0" specifies :
  not to show the the "reducible" fraction
  i.e. 2/6 = 3/9 = 4/12 = .. are hidden.

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Example 2:
proportions with **a common denominator**

```
> tabs -4
> denomfind -y3..4 -D5% 63.3% 54.6% 13.3% 10.3%
denom   fit 0.633     0.546      0.133      0.103
196 3   124/196=63.26531%  107/196=54.59184%   26/196=13.26531%   [20.09 20.286)
218 3   138/218=63.30275%  119/218=54.58716%   29/218=13.30275%   [22.345 22.563)
240 3   152/240=63.33333%  131/240=54.58333%   32/240=13.33333%   [24.6 24.84)
271 3   [171.4075 171.6785) 148/271=54.61255%   36/271=13.28413%   28/271=10.33210%
300 3   190/300=63.33333%  [163.65 163.95) 40/300=13.33333%   31/300=10.33333%
324 3   205/324=63.27160%  177/324=54.62963%   43/324=13.27160%   [33.21 33.534)
330 3   209/330=63.33333%  [180.015 180.345)   44/330=13.33333%   34/330=10.30303%
339 3   [214.4175 214.7565) 185/339=54.57227%   45/339=13.27434%   35/339=10.32448%
346 3   219/346=63.29480%  189/346=54.62428%   46/346=13.29480%   [35.465 35.811)
360 3   228/360=63.33333%  [196.38 196.74) 48/360=13.33333%   37/360=10.27778%
368 4   233/368=63.31522%  201/368=54.61957%   49/368=13.31522%   38/368=10.32609%
377 3   [238.4525 238.8295) 206/377=54.64191%   50/377=13.26260%   39/377=10.34483%
4 ratios are given. 12 denominators have found up to 377. (denomfind)
```

- The output forms **a TSV table**.

- The **right 4 columns** here corresponds with proportions 63.3%, 54.6%, 13.3%, 10.3%.

- The 2nd column *fit* means how many among the (4) proportions can get at least a numerator $\in \mathbb{Z}$ with each **denom** value.

- **-y3..4** specifies filtering on *fit*. i.e. *fit* with the value 0,1,2 are omitted.

- **-D5%** specifies to show the retrieved fraction value with 5 decimal places in %.

- The intervals in faint color indicate the set of the possible numerator on $\mathbb{R}$, which does not contain any integer $\mathbb{Z}$.

- The command **tabs -4** adjusts the screen setting of tab intervals.

- The smallest possible denominator $\in \mathbb{N}$ to yield the 4 rounded proportions is **368**.

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Usage of denomfind

1. To **<u>find</u>** the possible denominator
   with given multiple rounded proportions.

   - One can check whether the sample size is large enough.

2. To **<u>check</u>** and to **<u>correct</u>** the numbers
   such as denominator and rounded proportions.

   - Quite often, numbers appearing on reports contain a small number of mistakes.

3. To know how the proportions are rounded.

   - If the <u>rounding half up</u> is performed on a number <u>twice</u> in a specific way, 3.45% can turn to be 4% via 3.5%.

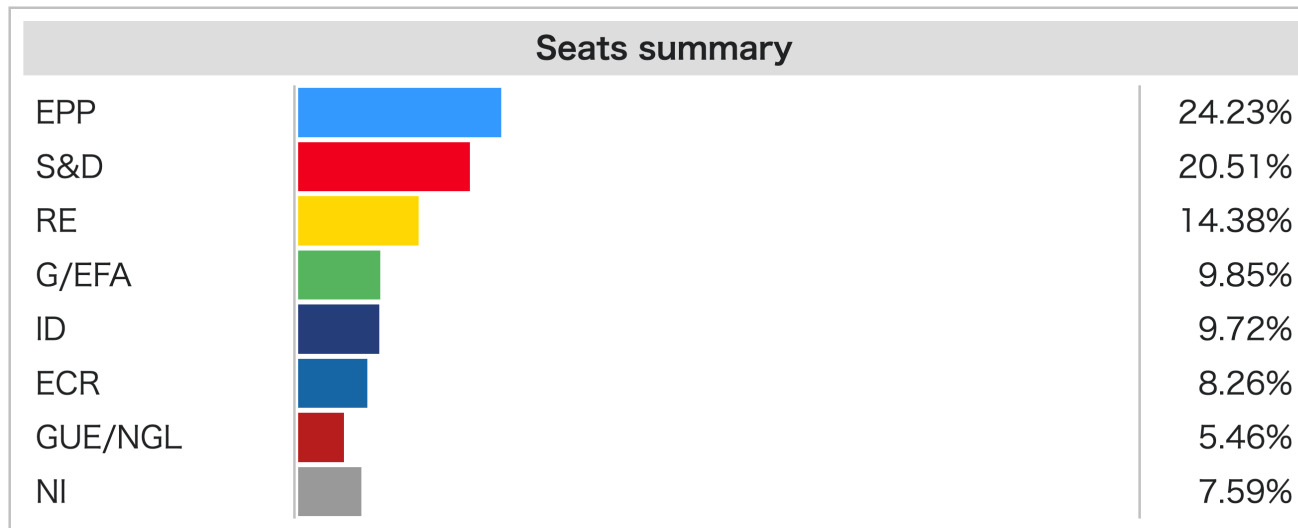   - Deciphering how the numbers are rounded may conclude **how carefully the document is yielded**.

Feature of denomfind

Simple interface despite the various options.
— How to interact with the program is intentionally designed.

1. Run such as **denomfind 0.167 0.714** firstly.

2. The output is easily understandable.

3. You gradually increase functions to use
   such as options and other commands.

4. The necessary functions are abundantly provided.

5. Online manual is provided : **denomfind --help**

6. Demo is also provided.
   You can try **denomfind –T1** (1 is changeable.)

Example 3. Seats summary of
2019 European Parliament Election

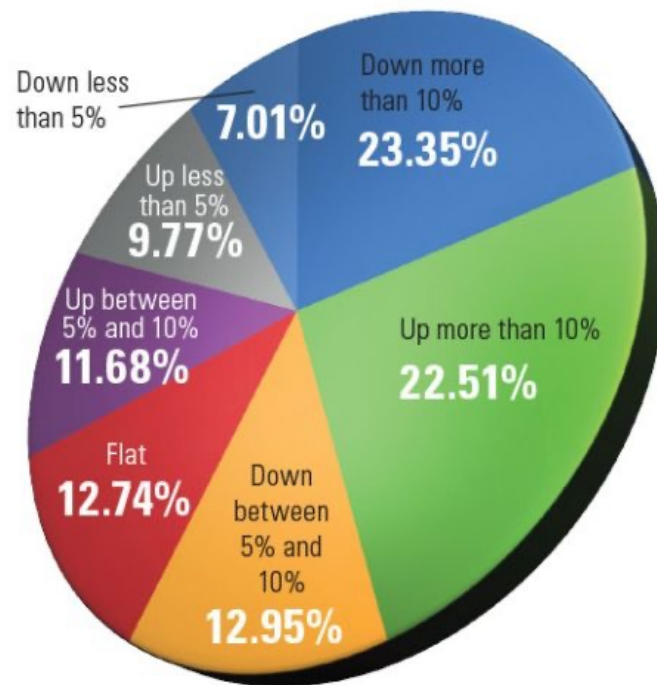| Seats summary	
EPP	24.23%
S&D	20.51%
RE	14.38%
G/EFA	9.85%
ID	9.72%
ECR	8.26%
GUE/NGL	5.46%
NI	7.59%

```
> tabs -6
> denomfind -y, -g7 -% 24.23 20.51 14.38 9.85 9.72 8.26 5.46 7.59
denom fit  0.2423     0.2051     0.1438     0.0985     0.0972     0.0826     0.0546     0.0759
751   8    182/751    154/751    108/751    74/751     73/751     62/751     41/751     57/751
1502. 8    364/1502   308/1502   216/1502   148/1502   146/1502   124/1502   82/1502    114/1502
2253. 8    546/2253   462/2253   324/2253   222/2253   219/2253   186/2253   123/2253   171/2253
3004. 8    728/3004   616/3004   432/3004   296/3004   292/3004   248/3004   164/3004   228/3004
3755. 8    910/3755   770/3755   540/3755   370/3755   365/3755   310/3755   205/3755   285/3755
3900  8    945/3900   800/3900   561/3900   384/3900   379/3900   322/3900   213/3900   296/3900
4032  8    977/4032   827/4032   580/4032   397/4032   392/4032   333/4032   220/4032   306/4032
8 ratios are given. 7 denominators have found up to 4032. (denomfind)
>
```

The total seat number seems **751** (if < 1000)
  from the 8 proportion percentages.
–y, filters the *fit* number being the largest (8; the number of proportions).
–g7 specifies to get 7 candidates. **–%** specifies percentages are given.

Example4. From a pie chart.

GROWERS: HOW DOES YOUR OPERATION'S 2015 PRODUCTION COMPARE TO 2014?

Down less than 5%
Down more than 10% **23.35%**
Up less than 5% **9.77%**
Up between 5% and 10% **11.68%**
Flat **12.74%**
Down between 5% and 10% **12.95%**
Up more than 10% **22.51%**
7.01%

```
> denomfind  -M0 -a0.01%  -y, -% 23.35 22.51 12.95 12.74 11.68 9.77 7.01
denom     fit     0.2335    0.2251   0.1295   0.1274   0.1168   0.0977   0.0701
471       7       110/471   106/471  61/471   60/471   55/471   46/471   33/471
2270      7       530/2270 511/2270 294/2270 289/2270 265/2270 222/2270 159/2270
2425      7       566/2425 546/2425 314/2425 309/2425 283/2425 237/2425 170/2425
2510      7       586/2510 565/2510 325/2510 320/2510 293/2510 245/2510 176/2510
2527      7       590/2527 569/2527 327/2527 322/2527 295/2527 247/2527 177/2527
2612      7       610/2612 588/2612 338/2612 333/2612 305/2612 255/2612 183/2612
2639      7       616/2639 594/2639 342/2639 336/2639 308/2639 258/2639 185/2639
2724      7       636/2724 613/2724 353/2724 347/2724 318/2724 266/2724 191/2724
2741      7       640/2741 617/2741 355/2741 349/2741 320/2741 268/2741 192/2741
2835      7       662/2835 638/2835 367/2835 361/2835 331/2835 277/2835 199/2835
2866      7       669/2866 645/2866 371/2866 365/2866 335/2866 280/2866 201/2866
2879      7       672/2879 648/2879 373/2879 367/2879 336/2879 281/2879 202/2879
7 ratios are given. 12 denominators have found up to 2879. (denomfind)
>
```

The total number of answerer seems to be **471**.

"The response was overwhelming, as **750** of you weighed in — including **545** growers — providing valuable insight in an online survey."

https://www.growingproduce.com/fruits/fruit-growers-expect-sweet-16/

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Various options in rounding

Assuming the rounding

- "round down" (floor ; e.g. 0.345 → 0.34) : **–f**

- "round up" (ceil ; e.g. 0.345 → 0.35) : **–c**

- "round half up" is done twice (*e.g.* 0.345→0.35→0.4) : **-5 2**

- "round half to even" (e.g. 0.335 and 0.345 → 0.34) : **-5 e**

- "round half to odd" (e.g. 0.345 and 0.355 → 0.35) : **-5 o**

- Allowing the error within $\pm$ *1%* : **-a 0.01** or **-a 1%**

Options in the denominator filtering

- -g 100 : getting 100 candidates in denominators from the smallest (1).

- -g 123,100 : getting 100 candidates in denominators from the 123.

- -g 123,-10 : getting 10 candidates from the 123 in descending order.

- -y .. : showing **every denominator** as long as specified by **–g** option.

- -y , : only showing the denominators when **every given proportion**
       has at least one corresponding integer numerator.

- -y 1.. : showing the denominators when at least one of given proportion
        has the corresponding integer numerator. (**Default**)

- -y -2.. : showing the denominators when every given proportion
        has the corresponding integer numerator
        allowing the **exceptions** within 2 of the proportions.

N..M means the numerical range. N.. means n to the maximum. ..M means zero to M. When N or M is negative, it means (the maximum)-abs(N or M). Those types of range or a single number can be combined by comma(,).

Options in output

- -D0 : showing the fraction form such as **10/33**. (**Default** ※)

- -D3 : showing also with 3 decimal places such as **10/33=.303**

- -D4% : in 4 decimal places in percentage such as **10/33=30.3030%**

- -D-5 : showing the difference to realize the given proportion with 5 decimal places **10/33-.00003** for a given proportion 0.303

- -D-6% : showing the difference to realize the given proportion with 6 decimal places such as **10/33-. 00303%** for a proportion 0.303

- **-I** : showing the interval of possible numerators on $\mathbb{R}$, not only $\mathbb{Z}$. If the interval contains any integer it is shown in green color.

- **-Q** : showing the numerators in a simplest way.
  Extra1. When only one proportion is given,
  the denominator is shown with its prime factorization as well.
  Extra2. To see all the numerators are odd (2q+1) or even (2q),
  if they have a common reminder R against a devisor D,
  they are shown with a form "(Dq+R)" as well.

※ If **–D** , **–I** and **–Q** are not given, **-D0** is regarded to be specified internally.