Multiple trajectory graphical iterator

Phileas Dazeley Gaist

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Graphical iterator program

I've written a simple graphical iterator program to help make graphical iterations on the fly. Here it is:

I can't guarantee it'll work for all functions you throw at it, but then again, I can't think of any reason why it wouldn't. Let me know if you come across any or issues!

Setup

```
# set your initial condition and desired number of iterations:
x_0s <- c(3.43, 4.43, 7)
N <- 100

# set the iteration plot x axis range (lower and upper bounds):
x_min <- 0; x_max <- 8
y_min <- -2; y_max <- 8

use_custom_range_x <- FALSE
use_custom_range_y <- FALSE

# declare your function here:
func <- function(x){
  return(-2 * sin(x) + x) # function goes here
}
```

The nitty-gritty

```
get_function_data <- function(range = c(-1, 1), steps = 100){

  steps_multiplier <- (range[2]-range[1])/10
  if(steps_multiplier < 1){steps_multiplier <- 1}
  # adds steps to get data for depending on the number of 10s
```

```
  # in the specified plot x range

  x <- seq(from = range[1], to = range[2], length.out = steps * steps_multiplier)

  y <- array(dim = steps * steps_multiplier)
  for(i in 1:length(x)){
    y[i] <- func(x[i])
    }

  return(data.frame(x = x, y = y))
}

graphical_iterator <- function(x_0s, N = 100){

  segments <- data.frame()
  for(i in x_0s){

    start <- i
    vert <- FALSE

    x_0 <- rep(i,times=1+(N*2))
    xstarts <- c(start)
    ystarts <- c(y_min)
    xends <- c(start)
    yends <- c(func(start))

    # iteratively get the coordinates of the next segment points
    for(i in 1:(2 * N))
      # range = 2 * N because every step will be described by two segments
    {
      # if the last segment was vertical, the next must be horizontal
      if(vert){
        xstarts <- c(xstarts, start)
        ystarts <- c(ystarts, start)
        xends <- c(xends, start)
        yends <- c(yends, func(start))
        vert <- FALSE
      }
      else{
        xstarts <- c(xstarts, start)
        ystarts <- c(ystarts, func(start))
        xends <- c(xends, func(start))
        yends <- c(yends, func(start))
        vert <- TRUE
        start <- func(start) # update start value
      }
    }
```

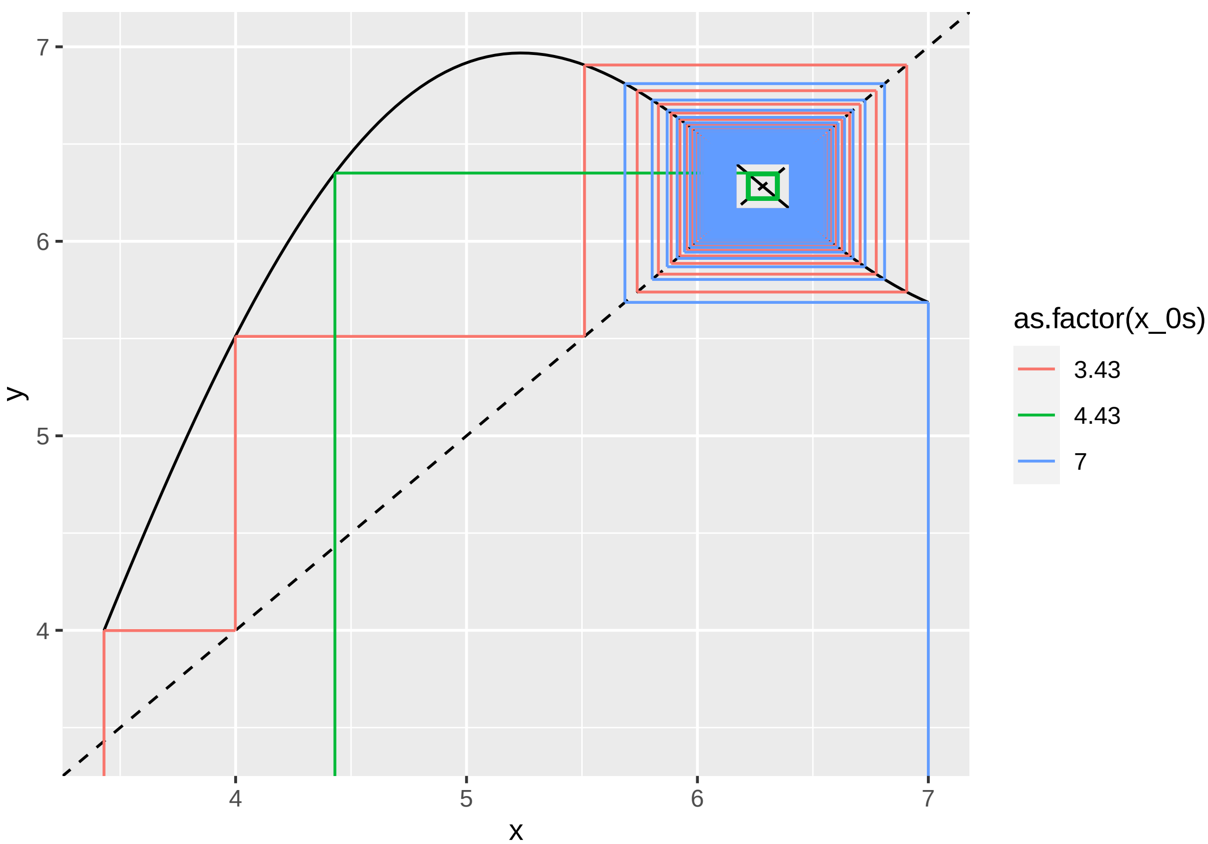
```
    segments <- rbind(segments, data.frame(x_0s = x_0, xstarts, ystarts, xends, yends))
  }
  return(segments)
}

cobweb_trajects <- graphical_iterator(x_0s = x_0s, N = N)

if(use_custom_range_x == FALSE){
  x_min <- min(cobweb_trajects$xstarts); x_max <- max(cobweb_trajects$xends)
}
if(use_custom_range_y == FALSE){
  y_min <- min(cobweb_trajects$xstarts); y_max <- max(cobweb_trajects$xends)
}

plot_data <- get_function_data(range = c(x_min,x_max)) # gets the plotting data

get_function_iteration_trajectories <- function(x_0s, N = 100){

  trajectories <- data.frame()

  for(i in x_0s){
    x_t <- i

    x_0 <- rep(i,times=N+1)
    n <- 0:N

    trajectory <- c(x_t)

    for(t in 0:(N-1)){
      x_t <- func(x_t)
      trajectory <- c(trajectory, x_t) # add x_t_1's value to the trajectory vector
    }
    trajectories <- rbind(trajectories, data.frame(x_0s = x_0, ns = n, trajectories = trajecto
  }
  return(trajectories)
}

trajectories <- get_function_iteration_trajectories(x_0s = x_0s, N = N)
```

Plots

Graphical iteration plot:

```
plot_data %>%
  ggplot(aes(x, y)) +
  geom_line(colour = "black") +
```

```
  geom_abline(linetype = "dashed") +
  geom_segment(data = cobweb_trajects, aes(x = xstarts, y = ystarts, xend = xends,
                                           yend = yends, colour=as.factor(x_0s))) +
  coord_cartesian(xlim = c(x_min, x_max), ylim = c(y_min, y_max))
```



TODO IN THE FUTURE:

- Colour segments based on distance to fixed points.
- Colour segments based on distance to other segments.

Iteration trajectory time series plot

```
trajectories
```

```
##      x_0s  ns trajectories
## 1    3.43   0     3.430000
## 2    3.43   1     3.998851
## 3    3.43   2     5.510954
## 4    3.43   3     6.906425
## 5    3.43   4     5.739087
## 6    3.43   5     6.774380
## 7    3.43   6     5.831020
```

```
## 8   3.43   7      6.704848
## 9   3.43   8      5.886292
## 10  3.43   9      6.659402
## 11  3.43  10      5.924593
## 12  3.43  11      6.626506
## 13  3.43  12      5.953274
## 14  3.43  13      6.601192
## 15  3.43  14      5.975844
## 16  3.43  15      6.580895
## 17  3.43  16      5.994232
## 18  3.43  17      6.564130
## 19  3.43  18      6.009603
## 20  3.43  19      6.549967
## 21  3.43  20      6.022710
## 22  3.43  21      6.537790
## 23  3.43  22      6.034065
## 24  3.43  23      6.527168
## 25  3.43  24      6.044029
## 26  3.43  25      6.517795
## 27  3.43  26      6.052868
## 28  3.43  27      6.509441
## 29  3.43  28      6.060781
## 30  3.43  29      6.501932
## 31  3.43  30      6.067919
## 32  3.43  31      6.495134
## 33  3.43  32      6.074403
## 34  3.43  33      6.488940
## 35  3.43  34      6.080328
## 36  3.43  35      6.483266
## 37  3.43  36      6.085769
## 38  3.43  37      6.478042
## 39  3.43  38      6.090790
## 40  3.43  39      6.473211
## 41  3.43  40      6.095443
## 42  3.43  41      6.468726
## 43  3.43  42      6.099770
## 44  3.43  43      6.464547
## 45  3.43  44      6.103809
## 46  3.43  45      6.460641
## 47  3.43  46      6.107589
## 48  3.43  47      6.456979
## 49  3.43  48      6.111139
## 50  3.43  49      6.453537
## 51  3.43  50      6.114479
## 52  3.43  51      6.450293
## 53  3.43  52      6.117631
## 54  3.43  53      6.447230
## 55  3.43  54      6.120611
```

```
## 56  3.43  55      6.444330
## 57  3.43  56      6.123434
## 58  3.43  57      6.441579
## 59  3.43  58      6.126114
## 60  3.43  59      6.438966
## 61  3.43  60      6.128663
## 62  3.43  61      6.436479
## 63  3.43  62      6.131091
## 64  3.43  63      6.434108
## 65  3.43  64      6.133407
## 66  3.43  65      6.431845
## 67  3.43  66      6.135619
## 68  3.43  67      6.429681
## 69  3.43  68      6.137736
## 70  3.43  69      6.427610
## 71  3.43  70      6.139764
## 72  3.43  71      6.425624
## 73  3.43  72      6.141709
## 74  3.43  73      6.423719
## 75  3.43  74      6.143576
## 76  3.43  75      6.421889
## 77  3.43  76      6.145371
## 78  3.43  77      6.420128
## 79  3.43  78      6.147098
## 80  3.43  79      6.418434
## 81  3.43  80      6.148761
## 82  3.43  81      6.416801
## 83  3.43  82      6.150364
## 84  3.43  83      6.415226
## 85  3.43  84      6.151911
## 86  3.43  85      6.413706
## 87  3.43  86      6.153405
## 88  3.43  87      6.412237
## 89  3.43  88      6.154849
## 90  3.43  89      6.410818
## 91  3.43  90      6.156246
## 92  3.43  91      6.409444
## 93  3.43  92      6.157597
## 94  3.43  93      6.408114
## 95  3.43  94      6.158906
## 96  3.43  95      6.406825
## 97  3.43  96      6.160175
## 98  3.43  97      6.405575
## 99  3.43  98      6.161406
## 100 3.43  99      6.404363
## 101 3.43 100      6.162600
## 102 4.43   0      4.430000
## 103 4.43   1      6.350785
```

```
## 104 4.43   2      6.215689
## 105 4.43   3      6.350580
## 106 4.43   4      6.215893
## 107 4.43   5      6.350376
## 108 4.43   6      6.216096
## 109 4.43   7      6.350174
## 110 4.43   8      6.216297
## 111 4.43   9      6.349974
## 112 4.43  10      6.216496
## 113 4.43  11      6.349776
## 114 4.43  12      6.216693
## 115 4.43  13      6.349580
## 116 4.43  14      6.216888
## 117 4.43  15      6.349385
## 118 4.43  16      6.217082
## 119 4.43  17      6.349192
## 120 4.43  18      6.217274
## 121 4.43  19      6.349001
## 122 4.43  20      6.217465
## 123 4.43  21      6.348811
## 124 4.43  22      6.217653
## 125 4.43  23      6.348623
## 126 4.43  24      6.217841
## 127 4.43  25      6.348437
## 128 4.43  26      6.218026
## 129 4.43  27      6.348252
## 130 4.43  28      6.218210
## 131 4.43  29      6.348069
## 132 4.43  30      6.218393
## 133 4.43  31      6.347887
## 134 4.43  32      6.218574
## 135 4.43  33      6.347707
## 136 4.43  34      6.218753
## 137 4.43  35      6.347529
## 138 4.43  36      6.218931
## 139 4.43  37      6.347351
## 140 4.43  38      6.219107
## 141 4.43  39      6.347176
## 142 4.43  40      6.219282
## 143 4.43  41      6.347001
## 144 4.43  42      6.219456
## 145 4.43  43      6.346828
## 146 4.43  44      6.219628
## 147 4.43  45      6.346657
## 148 4.43  46      6.219799
## 149 4.43  47      6.346487
## 150 4.43  48      6.219968
## 151 4.43  49      6.346318
```

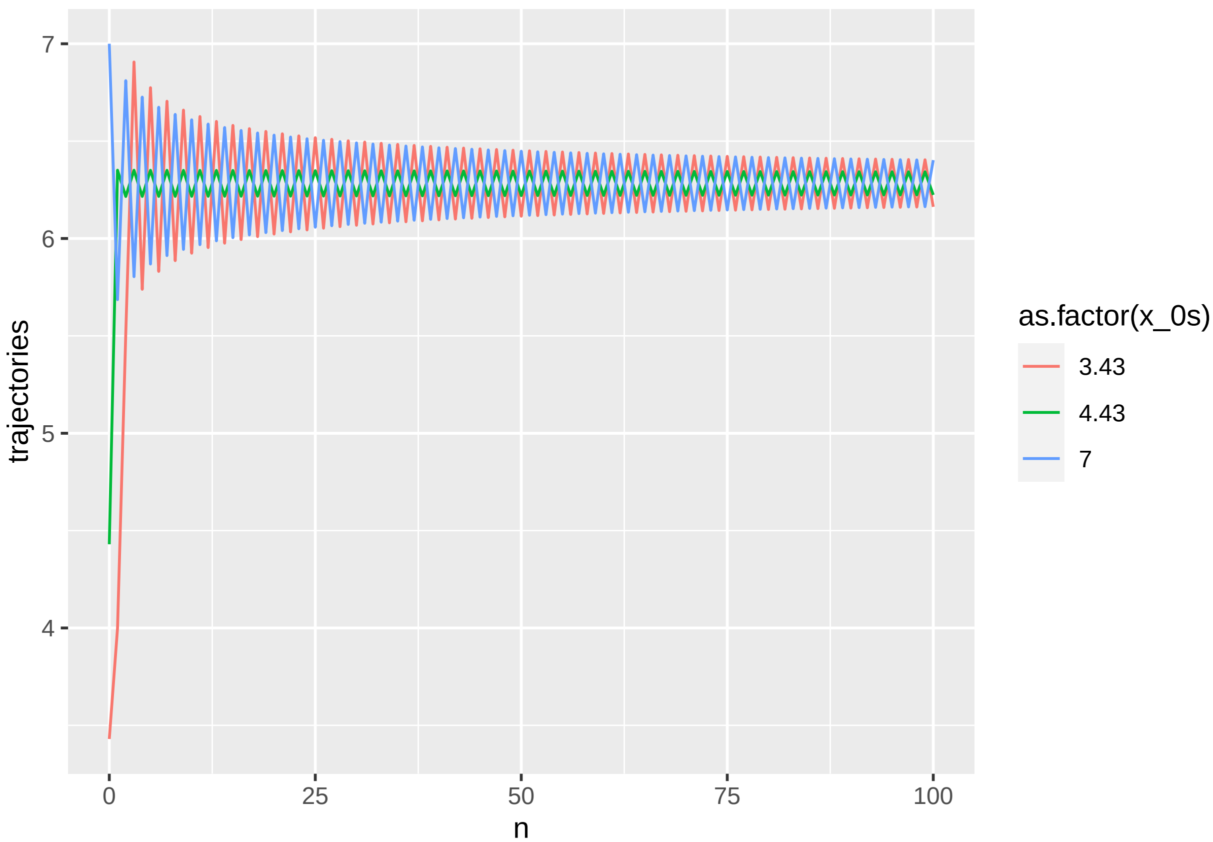
```
## 152 4.43  50      6.220136
## 153 4.43  51      6.346151
## 154 4.43  52      6.220303
## 155 4.43  53      6.345985
## 156 4.43  54      6.220468
## 157 4.43  55      6.345820
## 158 4.43  56      6.220633
## 159 4.43  57      6.345656
## 160 4.43  58      6.220795
## 161 4.43  59      6.345494
## 162 4.43  60      6.220957
## 163 4.43  61      6.345333
## 164 4.43  62      6.221117
## 165 4.43  63      6.345174
## 166 4.43  64      6.221276
## 167 4.43  65      6.345015
## 168 4.43  66      6.221434
## 169 4.43  67      6.344858
## 170 4.43  68      6.221591
## 171 4.43  69      6.344702
## 172 4.43  70      6.221746
## 173 4.43  71      6.344547
## 174 4.43  72      6.221901
## 175 4.43  73      6.344393
## 176 4.43  74      6.222054
## 177 4.43  75      6.344241
## 178 4.43  76      6.222206
## 179 4.43  77      6.344089
## 180 4.43  78      6.222357
## 181 4.43  79      6.343939
## 182 4.43  80      6.222506
## 183 4.43  81      6.343790
## 184 4.43  82      6.222655
## 185 4.43  83      6.343642
## 186 4.43  84      6.222803
## 187 4.43  85      6.343495
## 188 4.43  86      6.222949
## 189 4.43  87      6.343349
## 190 4.43  88      6.223094
## 191 4.43  89      6.343204
## 192 4.43  90      6.223239
## 193 4.43  91      6.343060
## 194 4.43  92      6.223382
## 195 4.43  93      6.342917
## 196 4.43  94      6.223524
## 197 4.43  95      6.342775
## 198 4.43  96      6.223666
## 199 4.43  97      6.342635
```

```
## 200 4.43  98      6.223806
## 201 4.43  99      6.342495
## 202 4.43 100      6.223945
## 203 7.00   0      7.000000
## 204 7.00   1      5.686027
## 205 7.00   2      6.810617
## 206 7.00   3      5.803986
## 207 7.00   4      6.726124
## 208 7.00   5      5.868931
## 209 7.00   6      6.673946
## 210 7.00   7      5.912163
## 211 7.00   8      6.637300
## 212 7.00   9      5.943780
## 213 7.00  10      6.609633
## 214 7.00  11      5.968272
## 215 7.00  12      6.587740
## 216 7.00  13      5.988003
## 217 7.00  14      6.569831
## 218 7.00  15      6.004358
## 219 7.00  16      6.554815
## 220 7.00  17      6.018212
## 221 7.00  18      6.541979
## 222 7.00  19      6.030149
## 223 7.00  20      6.530838
## 224 7.00  21      6.040580
## 225 7.00  22      6.521045
## 226 7.00  23      6.049799
## 227 7.00  24      6.512346
## 228 7.00  25      6.058026
## 229 7.00  26      6.504550
## 230 7.00  27      6.065428
## 231 7.00  28      6.497509
## 232 7.00  29      6.072136
## 233 7.00  30      6.491108
## 234 7.00  31      6.078252
## 235 7.00  32      6.485256
## 236 7.00  33      6.083860
## 237 7.00  34      6.479876
## 238 7.00  35      6.089026
## 239 7.00  36      6.474909
## 240 7.00  37      6.093806
## 241 7.00  38      6.470305
## 242 7.00  39      6.098246
## 243 7.00  40      6.466020
## 244 7.00  41      6.102385
## 245 7.00  42      6.462019
## 246 7.00  43      6.106255
## 247 7.00  44      6.458272
```

```
## 248 7.00  45      6.109885
## 249 7.00  46      6.454754
## 250 7.00  47      6.113298
## 251 7.00  48      6.451441
## 252 7.00  49      6.116516
## 253 7.00  50      6.448314
## 254 7.00  51      6.119556
## 255 7.00  52      6.445357
## 256 7.00  53      6.122434
## 257 7.00  54      6.442554
## 258 7.00  55      6.125164
## 259 7.00  56      6.439893
## 260 7.00  57      6.127759
## 261 7.00  58      6.437362
## 262 7.00  59      6.130229
## 263 7.00  60      6.434950
## 264 7.00  61      6.132584
## 265 7.00  62      6.432649
## 266 7.00  63      6.134834
## 267 7.00  64      6.430450
## 268 7.00  65      6.136984
## 269 7.00  66      6.428346
## 270 7.00  67      6.139043
## 271 7.00  68      6.426330
## 272 7.00  69      6.141017
## 273 7.00  70      6.424397
## 274 7.00  71      6.142912
## 275 7.00  72      6.422540
## 276 7.00  73      6.144732
## 277 7.00  74      6.420755
## 278 7.00  75      6.146483
## 279 7.00  76      6.419037
## 280 7.00  77      6.148169
## 281 7.00  78      6.417382
## 282 7.00  79      6.149793
## 283 7.00  80      6.415787
## 284 7.00  81      6.151360
## 285 7.00  82      6.414248
## 286 7.00  83      6.152873
## 287 7.00  84      6.412761
## 288 7.00  85      6.154334
## 289 7.00  86      6.411324
## 290 7.00  87      6.155748
## 291 7.00  88      6.409934
## 292 7.00  89      6.157115
## 293 7.00  90      6.408588
## 294 7.00  91      6.158439
## 295 7.00  92      6.407285
```

```
## 296 7.00  93     6.159722
## 297 7.00  94     6.406021
## 298 7.00  95     6.160967
## 299 7.00  96     6.404796
## 300 7.00  97     6.162174
## 301 7.00  98     6.403607
## 302 7.00  99     6.163346
## 303 7.00 100     6.402452
```

```
# trajectory plot
trajectories %>%
  ggplot(aes(ns, trajectories, colour = as.factor(x_0s))) +
  geom_line() + labs(x="n")
```




```
# TODO
# average distances between trajectories plot

# mean(dist(c(1:10))) # mean of distances between whole numbers from 1 to 10 (example)

# trajectories$x_0s <- paste0('x_0_', trajectories$x_0s)
# trajectories_wide <- trajectories %>%
#   pivot_wider(names_from = x_0s, values_from = trajectories) %>%
#   mutate(distance = (x_0_2.01-x_0_2))
```

```r
#
# trajectories_wide
#
# trajectories_wide %>%
#   ggplot(aes(ns, distance)) +
#   geom_point() + geom_line() +
#   labs(x="n", y="distance between trajectories")
```