Optional Exercise

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In this session

- Notes on the Special Exercise

- Some code to get you started

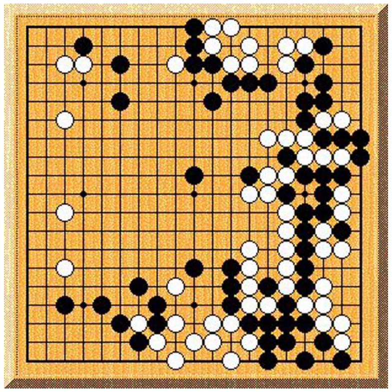
Before going further, please take a few minutes to read the exercise.

In this session

Why are we doing this?

- Practice writing loops – over rows & columns
- Practice breaking a multi-step job into component parts, and doing each of them in turn

This is a simple evolutionary model – the simplest Conway could devise that does anything useful, or interesting. Much of what he learned/proved about it was based on computer simulations, like ours.



It was devised in 1970, and early, error-prone experimentation was done on a Go board.

Conway's Game of Life: The Rules

Cells live on a grid, they can be alive (1) or dead (0). At each generation they have a number of live neighbors – defined at the 8 surrounding cells.

Cells live, die, and become alive according to these rules;

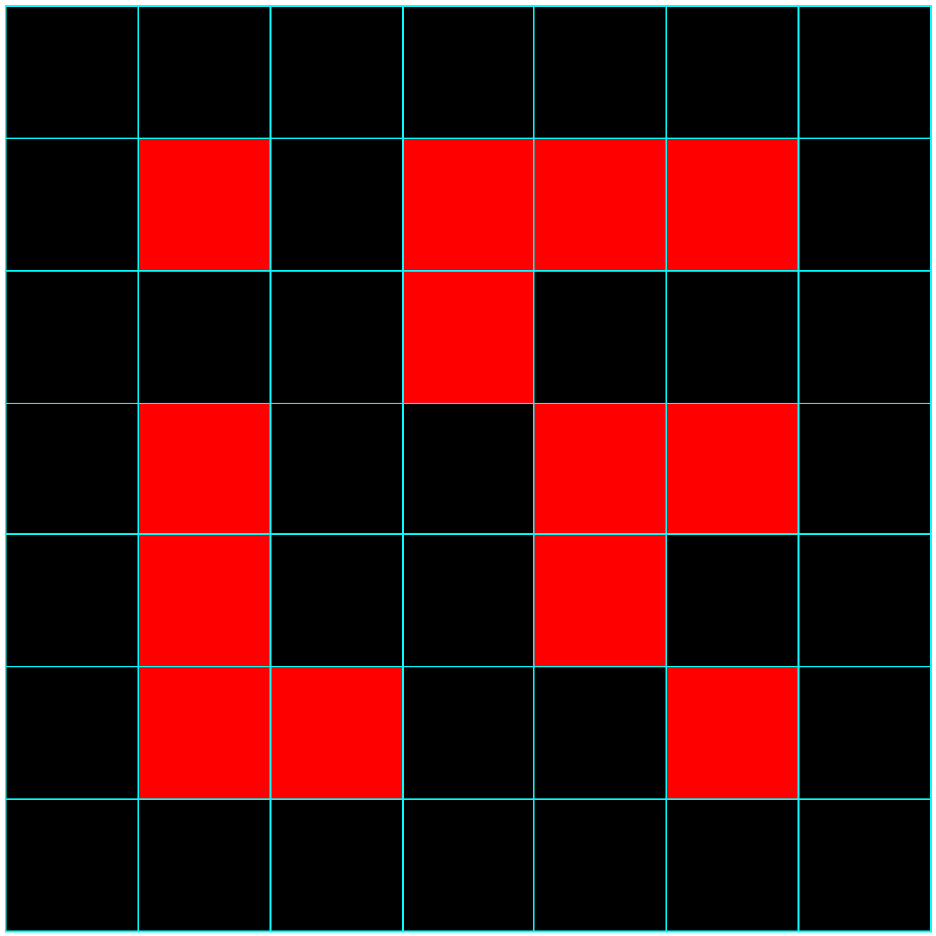
If alive==1 and #neighbors <2,	alive <– 0
If alive==1 and #neighbors ==2 or 3,	alive <– 1
If alive==1 and #neighbors >3,	alive <– 0
If alive==0 and #neighbors ==3,	alive <– 1

– other dead cells stay dead.

(NB nothing is random here – deliberately! – but it's also straightforward to allow life/death to be *somewhat* stochastic)

Conway's Game of Life: The Rules

An example update;



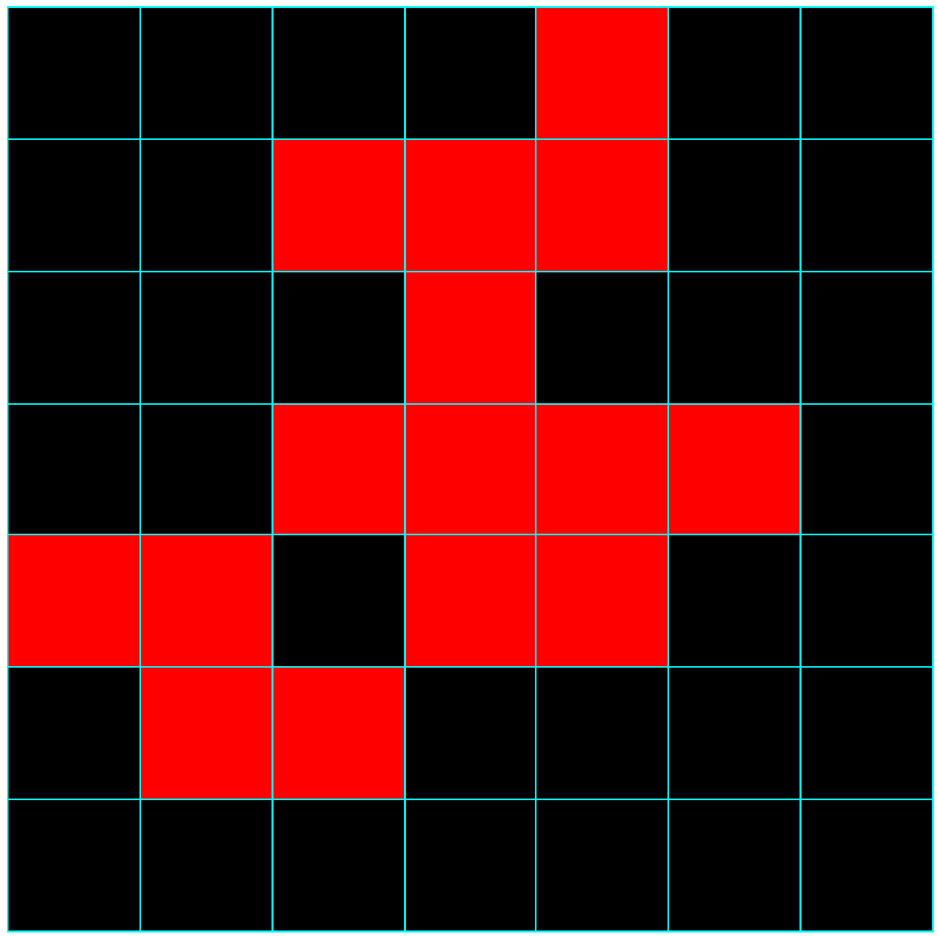
Conway's Game of Life: The Rules

An example update;

1	1	2	2	3	2	1
1	0	3	2	3	1	1
2	2	4	3	6	4	2
2	1	3	3	3	2	1
3	3	4	3	3	4	2
2	2	2	2	2	1	1
1	2	2	1	1	1	1

Conway's Game of Life: The Rules

An example update;



Game of Life: What do we need?

Objects;

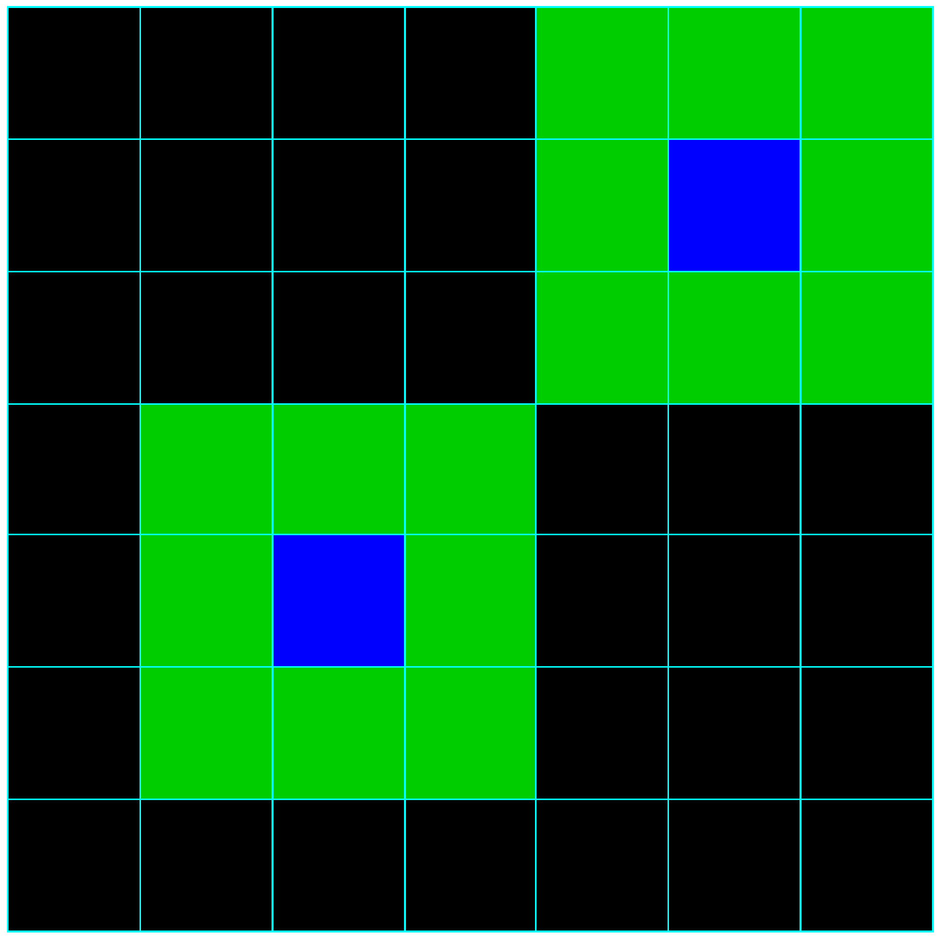
- A `matrix` of cells, each 1 or 0
- A `matrix` containing # neighbours each cell has
- Another `matrix` of cells, each 1 or 0 – containing the updated values

Code to do the following jobs;

- Count number of neighbors for cells
- Updating the alive/dead status
- Plot the current status, for all cells

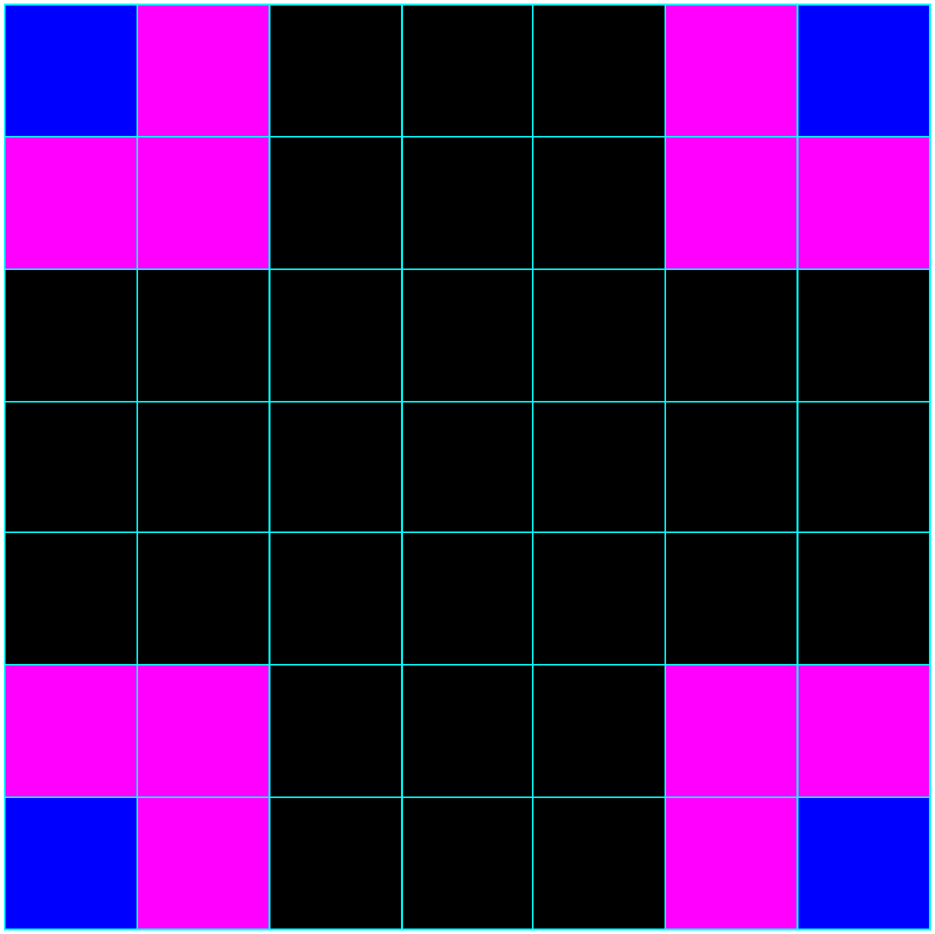
Game of Life: Counting neighbors

Most cells have 8 neighbors...



Game of Life: Counting neighbors

...but some ‘edge cases’ don’t (yuk!)



Game of Life: Counting neighbors

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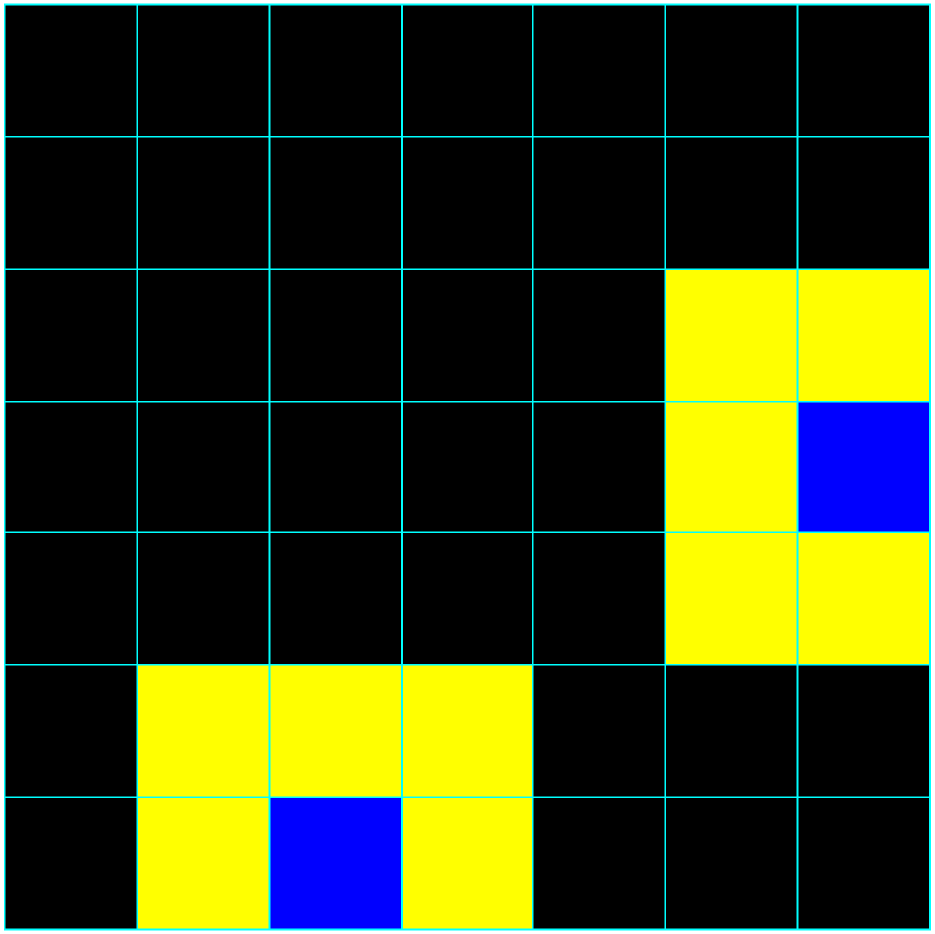
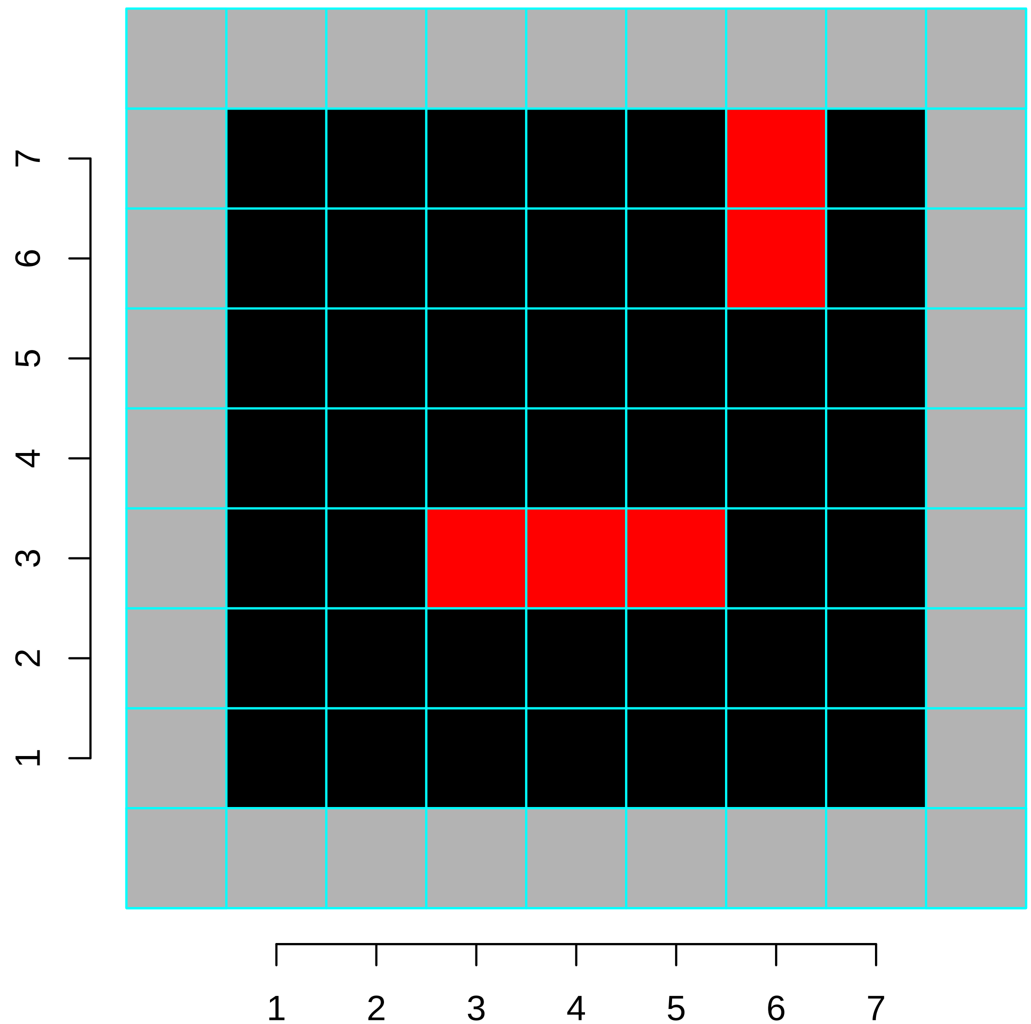


Game of Life: Counting neighbors

Easier: count on a grid with zeroed-out edges, don't plot them;



Game of Life: Counting neighbors

Some code to do the counting;

```
nrows <- 7
ncols <- 7
alive <- matrix(0, nrows+2, ncols+2) # "+2" is adding the gray border

# add some "alive" cells
alive[4,4:6] <- 1
alive[7:8,7] <- 1

# do the neighbour counting - only for the non-gray cells
neebs <- matrix(0, nrows+2, ncols+2)
for(i in 2:(nrows+1)){
   for(j in 2:(ncols+1)){
      neebs[i,j] <- alive[i-1,j-1] +
                    alive[i-1,j  ] +
                    alive[i-1,j+1] +
                    alive[i  ,j-1] +
                    alive[i  ,j+1] +
                    alive[i+1,j-1] +
                    alive[i+1,j  ] +
                    alive[i+1,j+1] # adding over the 8 neighbors
      } # close j loop
   }    # close i loop
```

Game of Life: Plotting status

There are many ways to plot the cells – `rect()` offers one simple way; if i indexes rows and j columns, we need e.g.

`xleft`	$j - 1/2$
`ybottom`	$i - 1/2$
`xright`	$j + 1/2$
`ytop`	$i - 1/2$

... and also specify `color` – e.g. 1 for black/dead, 2 for red/alive.

Recall Sessions 3/4; first set up an empty plot (`type="n"`) ...

```
plot(0,0, type="n", xlab="", ylab="", axes=F,
     xlim=c(0.5,nrows+0.5), ylim=c(0.5,ncols+0.5), asp=1)
```

... then add the cell entries – with another double loop.

```
for(i in 1:nrows){
   for(j in 1:ncols){
      rect(j-0.5,i-0.5,j+0.5,i+0.5,
            col=alive[i+1,j+1] + 1, border="cyan")
   }
}
```

Game of Life: Updating status

How to update? (recall the grey border trick, againt)

```
alive.new <- matrix(0, nrows+2, ncols+2) # note full of zeros
for(i in 2:(nrows+1)){
  for(j in 2:(ncols+1)){
    if(alive[i,j]==1 & neebs[i,j]<2     ){ alive.new[i,j] <- 0 }
    if(alive[i,j]==1 & neebs[i,j]%in%2:3){ alive.new[i,j] <- 1 }
    if(alive[i,j]==1 & neebs[i,j]>3     ){ alive.new[i,j] <- 0 }
    if(alive[i,j]==0 & neebs[i,j]==3    ){ alive.new[i,j] <- 1 }
  }
}
alive <- alive.new
```

Note: the other `alive==0` cells stay dead, so there's no need for another `if()` statement here

Game of Life: Bonus Tracks

Some code to check your counting;

```
for(i in 1:nrows){
    for(j in 1:ncols){
        text(j,i, neebs[i+1,j+1], col="white") }}
```

Why `text(j,i, ...)`? Note that `text()` takes x and y co-ordinates, which correspond to index j and i respectively – as with plotting status.

And finally...

Some pseudo-code; fill in the rest yourself – cut-and-pasting the parts from earlier slides.

```
nrows <- 7
ncols <- 7
alive <- # ...some initial state
plot(0,0 # ...set up the plot
         # ...plot the initial state

for k in (1:100){
   # count neighbors (a double loop)
   # update status - who lives/dies? (a double loop)
   alive <- alive.new
   # plot again (a double loop)
}
```

- Then... sit back and be mesmerized!
- Start with random entries, and try a (much) bigger grid

The End (for now)

Notes;

- The coding here is designed to be easy to read, not to be optimally fast – slow code that works is better than fast code that doesn't!

- In Session 10 we'll review some ways to speed up the code (and still have it work)

- ... and ways to have the grid 'wrap around'

- ... also ways to make animations