00:00:00,580 --> 00:00:28,870

[Music]

00:00:28,870 --> 00:00:31,519

hello and welcome to this presentation

00:00:31,519 --> 00:00:32,640

on John Conway's

00:00:32,640 --> 00:00:35,910

Game of Life

00:00:35,910 --> 00:00:35,920

The game of life is a

00:00:35,920 --> 00:00:37,750

The game of life is a cellular automation

00:00:37,750 --> 00:00:37,760

cellular automation

00:00:37,760 --> 00:00:41,590

invented by a Cambridge Mathematician

00:00:41,590 --> 00:00:41,600

John Conway

00:00:41,600 --> 00:00:45,510

This game consists of a collection of

cells

00:00:45,510 --> 00:00:45,520

cells

00:00:45,520 --> 00:00:48,320

based on a few mathematical rules

00:00:48,320 --> 00:00:51,430

The cells can live,

00:00:51,430 --> 00:00:55,189

the cells can die,

00:00:55,189 --> 00:00:58,709

or multiply

00:00:58,709 --> 00:00:59,760

Depending on the initial conditions,

00:00:59,760 --> 00:01:03,270

the cells form various patterns

00:01:03,270 --> 00:01:05,109

throughout the course of the game.

00:01:05,109 --> 00:01:06,479

Now, let's have a look at the rules of the game.

00:01:06,479 --> 00:01:09,750

This game consists of 4 rules that

00:01:09,750 --> 00:01:12,789

determine if a cell lives,

00:01:12,789 --> 00:01:12,799

or dies.

00:01:12,799 --> 00:01:15,190

All depends

00:01:15,190 --> 00:01:16,320

on how many of that cell's neighbors are alive

00:01:16,320 --> 00:01:19,670

The first rule;

00:01:19,670 --> 00:01:19,680

On birth

00:01:19,680 --> 00:01:23,040

Now, on the **birth of a cell**,

00:01:23,040 --> 00:01:26,479

**Each dead cell adjacent to exactly three live neighbors**

00:01:26,479 --> 00:01:30,230

**will become live in the next generation**

00:01:30,230 --> 00:01:30,240

*for example*

00:01:30,240 --> 00:01:32,560

Let us use the grid here,

00:01:32,560 --> 00:01:33,360

Using yellow post it

00:01:33,360 --> 00:01:36,390

to represent a live cell,

00:01:36,390 --> 00:01:36,400

a no post it

00:01:36,400 --> 00:01:38,870

to represent a dead cell,

00:01:38,870 --> 00:01:39,759

and a blue post it

00:01:39,759 --> 00:01:42,640

to underline a newborn cell

00:01:42,640 --> 00:01:44,000

which then just becomes

00:01:44,000 --> 00:01:47,280

a normal cell in yellow

00:01:47,280 --> 00:01:48,310

*for example*

00:01:48,310 --> 00:01:48,320

if we have cells

00:01:48,320 --> 00:01:52,310

In this configuration

00:01:52,310 --> 00:01:52,320

**The rule states that**

00:01:52,320 --> 00:01:55,600

**Each dead cell adjacent to three live neighbors**

00:01:55,600 --> 00:01:58,079

**will become live in the next generation.**

00:01:58,079 --> 00:02:00,799

Now in this case the neighbors mean

00:02:00,799 --> 00:02:03,990

left, right,

00:02:03,990 --> 00:02:04,000

to the top, to the bottom

00:02:04,000 --> 00:02:07,429

and diagonal.

00:02:07,429 --> 00:02:08,000

In this configuration we only

00:02:08,000 --> 00:02:11,280

have one dead neighbor that is

00:02:11,280 --> 00:02:13,599

adjacent to three live neighbors

00:02:13,599 --> 00:02:15,840

and that is here

00:02:15,840 --> 00:02:18,560

so we have one new born

00:02:18,560 --> 00:02:19,589

which then becomes live

00:02:19,589 --> 00:02:19,599

in the next generation.

00:02:19,599 --> 00:02:23,110

The next rule on

00:02:23,110 --> 00:02:23,120

**death by isolation**

00:02:23,120 --> 00:02:25,910

*states that*

00:02:25,910 --> 00:02:28,879

**Each live cell with one or few live neighbors will die in the next generation.**

00:02:28,879 --> 00:02:32,470

Now, let's look at the cell neighboring

00:02:32,470 --> 00:02:35,920

one live cell

00:02:35,920 --> 00:02:38,239

with the remaining neighbors dead.

00:02:38,239 --> 00:02:41,350

Applying the rules,

00:02:41,350 --> 00:02:41,360

this cell,

00:02:41,360 --> 00:02:45,680

dies because it is isolated.

00:02:45,680 --> 00:02:47,350

because there are only two cells alive

00:02:47,350 --> 00:02:47,360

Because there are only two cells alive

00:02:47,360 --> 00:02:48,800

in the board with only one

00:02:48,800 --> 00:02:51,120

live neighbor,

00:02:51,120 --> 00:02:53,190

and there are no dead cells

00:02:53,190 --> 00:02:53,200

that could possibly have

00:02:53,200 --> 00:02:55,270

three live neighbors,

00:02:55,270 --> 00:02:55,280

There will be no births

00:02:55,280 --> 00:02:57,440

even with a single cell on board

00:02:57,440 --> 00:03:00,869

with zero life neighbors.

00:03:00,869 --> 00:03:00,879

So all starting configurations

00:03:00,879 --> 00:03:02,400

with only

00:03:02,400 --> 00:03:05,910

a single cell

00:03:05,910 --> 00:03:05,920

will only

00:03:05,920 --> 00:03:09,200

contain dead cells in the next generation

00:03:09,200 --> 00:03:11,830

because of isolation.

00:03:11,830 --> 00:03:11,840

Let us look

00:03:11,840 --> 00:03:13,910

at the

00:03:13,910 --> 00:03:13,920

*third rule*

00:03:13,920 --> 00:03:15,990

**Death by Overcrowding**

00:03:15,990 --> 00:03:16,000

This rule states that,

00:03:16,000 --> 00:03:20,319

**Each live cell with four or more live neighbors**

00:03:20,319 --> 00:03:23,750

will die in the next generation as if by overcrowding

00:03:23,750 --> 00:03:23,760

*for example:* ***this***

00:03:23,760 --> 00:03:25,830

Applying the rules,

00:03:25,830 --> 00:03:27,280

A new cell is born here because

00:03:27,280 --> 00:03:29,920

it has exactly three live neighbors

00:03:29,920 --> 00:03:32,000

while this cell dies because it has four

00:03:32,000 --> 00:03:34,789

live neighbors,

00:03:34,789 --> 00:03:34,799

same to this cell here

00:03:34,799 --> 00:03:37,040

because it has four live neighbors

00:03:37,040 --> 00:03:40,400

and a new cell is born here because it has three

00:03:40,400 --> 00:03:44,480

live neighbors.

00:03:44,480 --> 00:03:53,190

Following the rules, this cell dies because of isolation -

00:03:53,190 --> 00:03:56,319

it had only one neighbor that is alive

00:03:56,319 --> 00:03:58,159

Same to this cell here

00:03:58,159 --> 00:04:01,589

In the next generation a new cell is born here

00:04:01,589 --> 00:04:03,840

because it has exactly three live neighbors

00:04:03,840 --> 00:04:06,959

while this cell dies because of isolation

00:04:06,959 --> 00:04:09,439

The same to this

00:04:09,439 --> 00:04:13,190

and our new configuration is this

00:04:13,190 --> 00:04:13,200

In this particular configuration

00:04:13,200 --> 00:04:14,789

continuing with the rules,

00:04:14,789 --> 00:04:14,799

continuing with the rules we know that

00:04:14,799 --> 00:04:17,359

we know that they all die in the next generation

00:04:17,359 --> 00:04:20,239

**Why?**

00:04:20,239 --> 00:04:21,600

Because in this case each cell will only

00:04:21,600 --> 00:04:24,390

have a maximum of one live neighbor

00:04:24,390 --> 00:04:29,189

there will be no births since there are fewer than three live cells

00:04:29,189 --> 00:04:36,479

So all the initial configurations will die in this last generation.

00:04:36,479 --> 00:04:40,070

and

Here is the **fourth rule**

00:04:40,070 --> 00:04:40,080

**Survival**

00:04:40,080 --> 00:04:43,919

This rule states that,

00:04:43,919 --> 00:04:50,469

**each live cell with either two or three live neighbors will remain live for the next generation**

00:04:50,469 --> 00:04:51,350

*for example*

00:04:51,350 --> 00:04:51,360

this configuration

00:04:51,360 --> 00:04:54,720

In this configuration each cell has three live neighbors;

00:04:54,720 --> 00:05:00,870

Cell one here has two, three and four as the neighbors

00:05:00,870 --> 00:05:04,390

Cell two here hasl one, three and four as the neighbors,

00:05:04,390 --> 00:05:04,400

same to

00:05:04,400 --> 00:05:07,600

Cell four with cell three, one and two and same to cell 3

00:05:07,600 --> 00:05:10,320

and most importantly

00:05:10,320 --> 00:05:12,950

All these rules apply

00:05:12,950 --> 00:05:13,990

to all the cells

00:05:13,990 --> 00:05:14,000

at the same time

00:05:14,000 --> 00:05:16,870

So we have;

00:05:16,870 --> 00:05:16,880

**Births as if by reproduction**,

00:05:16,880 --> 00:05:20,310

**Death by isolation as if by underpopulation**,

00:05:20,310 --> 00:05:22,880

**Death by overcrowding as if by our population,**

00:05:22,880 --> 00:05:26,390

and

00:05:26,390 --> 00:05:26,400

**Survival**

00:05:26,400 --> 00:05:30,560

Now, let's see what these simple rules can do

00:05:30,560 --> 00:05:33,199

Given a configuration like this:

00:05:33,199 --> 00:05:37,189

What do you think is going to happen to these cells?

00:05:37,189 --> 00:05:39,199

These cells can either be alive with tokens in

00:05:39,199 --> 00:05:42,390

or dead with no tokens in.

00:05:42,390 --> 00:05:42,400

In computer versions,

00:05:42,400 --> 00:05:49,749

live cells are represented by one color and dead cells by another or just a blank grid

00:05:49,749 --> 00:05:52,710

In theory,

00:05:52,710 --> 00:05:57,120

the size of the cell or the grid is infinite but small boards will do for the initial play

00:05:57,120 --> 00:06:03,749

This is a solitary game or one with just one player and the play of the typical game looks like this

00:06:03,749 --> 00:06:15,350

You can pause the video and try out this configuration by yourself

00:06:15,350 --> 00:06:15,360

[PAUSE]

00:06:15,360 --> 00:06:18,400

Let's apply the rules

00:06:18,400 --> 00:06:20,240

Things start to get more interesting here

00:06:20,240 --> 00:06:25,430

Starting with the initial setup here then

00:06:25,430 --> 00:06:25,440

We move on to the next generation

00:06:25,440 --> 00:06:27,120

and we apply the rules

00:06:27,120 --> 00:06:41,919

Most configurations of three are far enough apart that they die out in one or two generations

00:06:41,919 --> 00:06:44,240

but this is an exception

00:06:44,240 --> 00:06:49,110

Starting with the line of three cells,

00:06:49,110 --> 00:06:52,309

the two end cells will die because they had one neighbor each

00:06:52,309 --> 00:06:57,120

While the middle cell will survive because it had two live neighbors

00:06:57,120 --> 00:07:07,749

There will be two births and the new configuration in the next generation will be this

00:07:07,749 --> 00:07:15,270

The births occur in the two cells next to the surviving cell that were dead because

00:07:15,270 --> 00:07:21,029

each those positions is next to the three live starting positions

00:07:21,029 --> 00:07:23,280

This pattern will repeat in every second generation

00:07:23,280 --> 00:07:31,039

With the two end cells dying and new cells are born

00:07:31,039 --> 00:07:43,670

From a horizontal line to a vertical line of three

00:07:43,670 --> 00:07:46,150

The pattern is called a **blinker**

00:07:46,150 --> 00:07:49,749

While this one, as we had looked before it becomes stable

00:07:49,749 --> 00:07:58,080

Pause the video and try out yourself

00:07:58,080 --> 00:08:01,589

Applying the rules,

00:08:01,589 --> 00:08:06,070

The two live cells here die because of isolation

00:08:06,070 --> 00:08:09,270

We will remain with one live cell in the next generation

00:08:09,270 --> 00:08:16,000

The remaining live cell died because of isolation because the cells were further in the initial configuration

00:08:16,000 --> 00:08:23,280

While with this pattern a new cell is born here because it has exactly two live neighbors while this cell will die

00:08:23,280 --> 00:08:26,550

together with this because of isolation

00:08:26,550 --> 00:08:31,840

Giving us this arrangement in the next generation while this also reduces to nothing

00:08:31,840 --> 00:08:36,790

All the cells die because of isolation

00:08:36,790 --> 00:08:44,949

Now, how about a configuration like this called a **glider**

00:08:44,949 --> 00:08:44,959

[PAUSE]

00:08:44,959 --> 00:08:48,720

Now, stop the video here and try applying the rules

00:08:48,720 --> 00:08:56,470

You can also try the first steps of the glider here pausing the video

00:08:56,470 --> 00:08:56,480

[PAUSE]

00:08:56,480 --> 00:09:08,230

Applying the rules a new cell is born here and here while this cell dies of isolation and this one

00:09:08,230 --> 00:09:09,200

Giving this as the next generation

00:09:09,200 --> 00:09:22,000

In the following generation a new cell is born here and here well this cell dies because of overcrowding and this one dies because of isolation

00:09:22,000 --> 00:09:25,200

Resulting to this as the new configuration

00:09:25,200 --> 00:09:33,590

In the following generation a new cell is born here while this cell dies because of overcrowding same to this one because of overcrowding

00:09:33,590 --> 00:09:38,000

Sorry the first one here dies because of isolation

00:09:38,000 --> 00:09:45,279

a new cell is born here while this one dies because of isolation

00:09:45,279 --> 00:09:48,959

and this is the resulting configuration of the next generation

00:09:48,959 --> 00:09:52,080

Now, let us have a look at this cell in a computer version

00:09:52,080 --> 00:10:08,470

type in [***https://www.silvergames.com/en/game-of-life***](https://www.silvergames.com/en/game-of-life) at your computer

00:10:08,470 --> 00:10:09,269

then play full screen

00:10:09,269 --> 00:10:13,760

Use the control run to show what exists on the screen and set step to show step by step

00:10:13,760 --> 00:10:18,800

You can also use clear to clear the previous

00:10:18,800 --> 00:10:28,230

represent the trace of the dead cells

00:10:28,230 --> 00:10:45,360

Now these are the steps of a glider from this to this to this base to this with the pattern repeating itself back and forth

00:10:45,360 --> 00:10:51,120

Same pattern releasing itself now we can run to show how it glides on the screen

00:10:51,120 --> 00:10:57,590

Now that is how interesting these rules apply

00:10:57,590 --> 00:10:57,600

Have a look at the pattern

00:10:57,600 --> 00:11:00,240

Thanks for watching

00:11:00,240 --> 00:11:06,720

Try for yourself

Have fun