Introduction to Classification

Spring 2023

May 15 2023

Classification

Predicting what category a (future) observation falls into

Examples:

- **Astronomy:** Whether an exoplanet is habitable (or not)
- **Filtering:** Identify spam emails
- **Medicine:** Use lab results to determine who has a disease (or not)
- **Product preference:** make product recommendations based on past purchases


Fire can be deadly, destroying homes, wildlife habitat and timber, and polluting air with harmful emission

Predicting the next forest fire ..

Dataset

- contains a culmination of forest fire observations
- based on two regions of Algeria: the Bejaia region and the Sidi Bel-Abbes region.
- from June 2012 to September 2012

Click here to learn more about the dataset

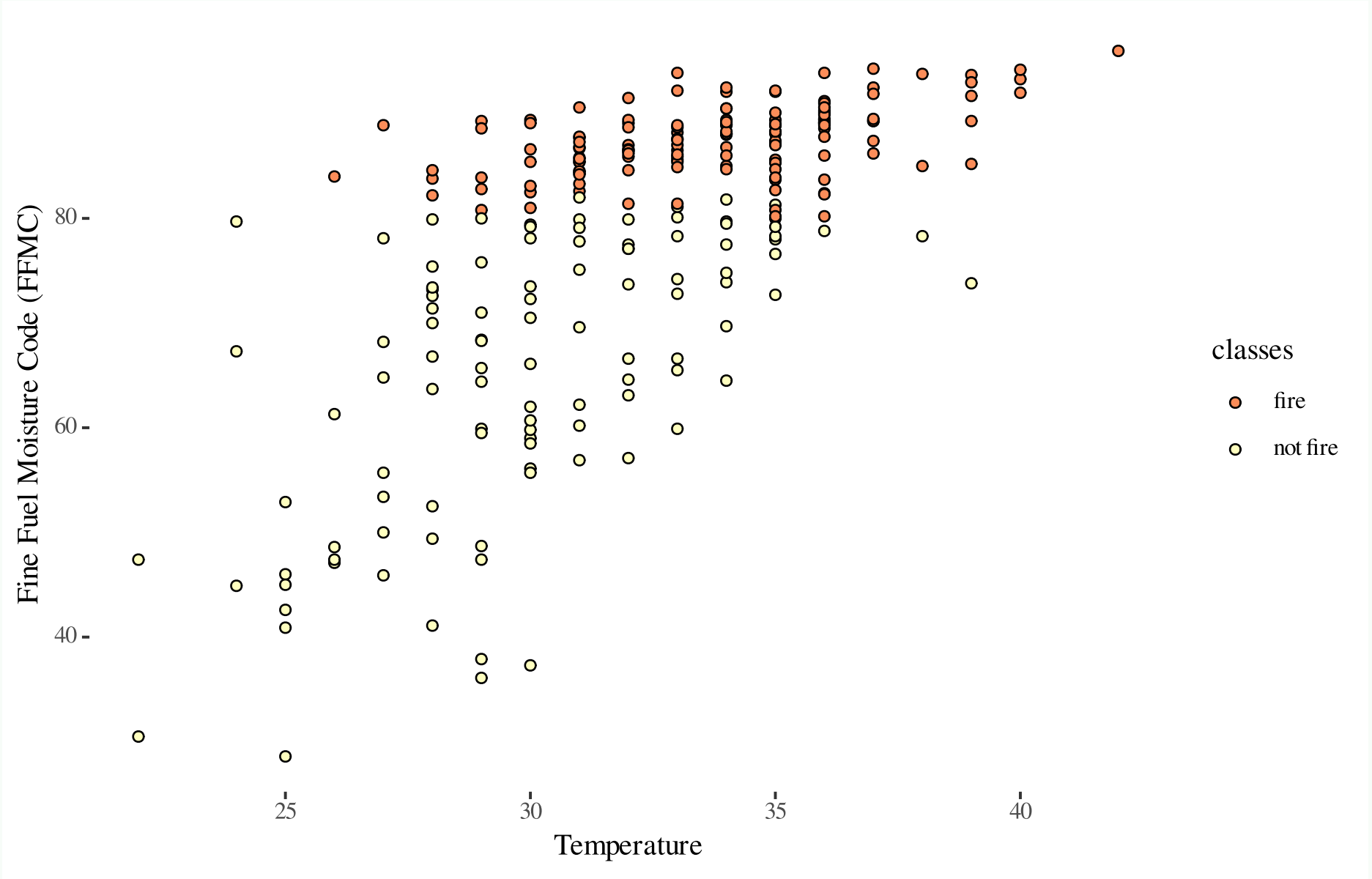
Data Description

Variable	Description
Date	(DD-MM-YYYY) Day, month, year
Temp	Noon temperature in Celsius degrees: 22 to 42
RH	Relative Humidity in percentage: 21 to 90
Ws	Wind speed in km/h: 6 to 29
Rain	Daily total rain in mm: 0 to 16.8
Fine Fuel Moisture Code (FFMC) index	28.6 to 92.5
Duff Moisture Code (DMC) index	1.1 to 65.9
Drought Code (DC) index	7 to 220.4
Initial Spread Index (ISI) index	0 to 18.5
Buildup Index (BUI) index	1.1 to 68
Fire Weather Index (FWI) index	0 to 31.1
Classes	Two classes, namely **fire** and **not fire**

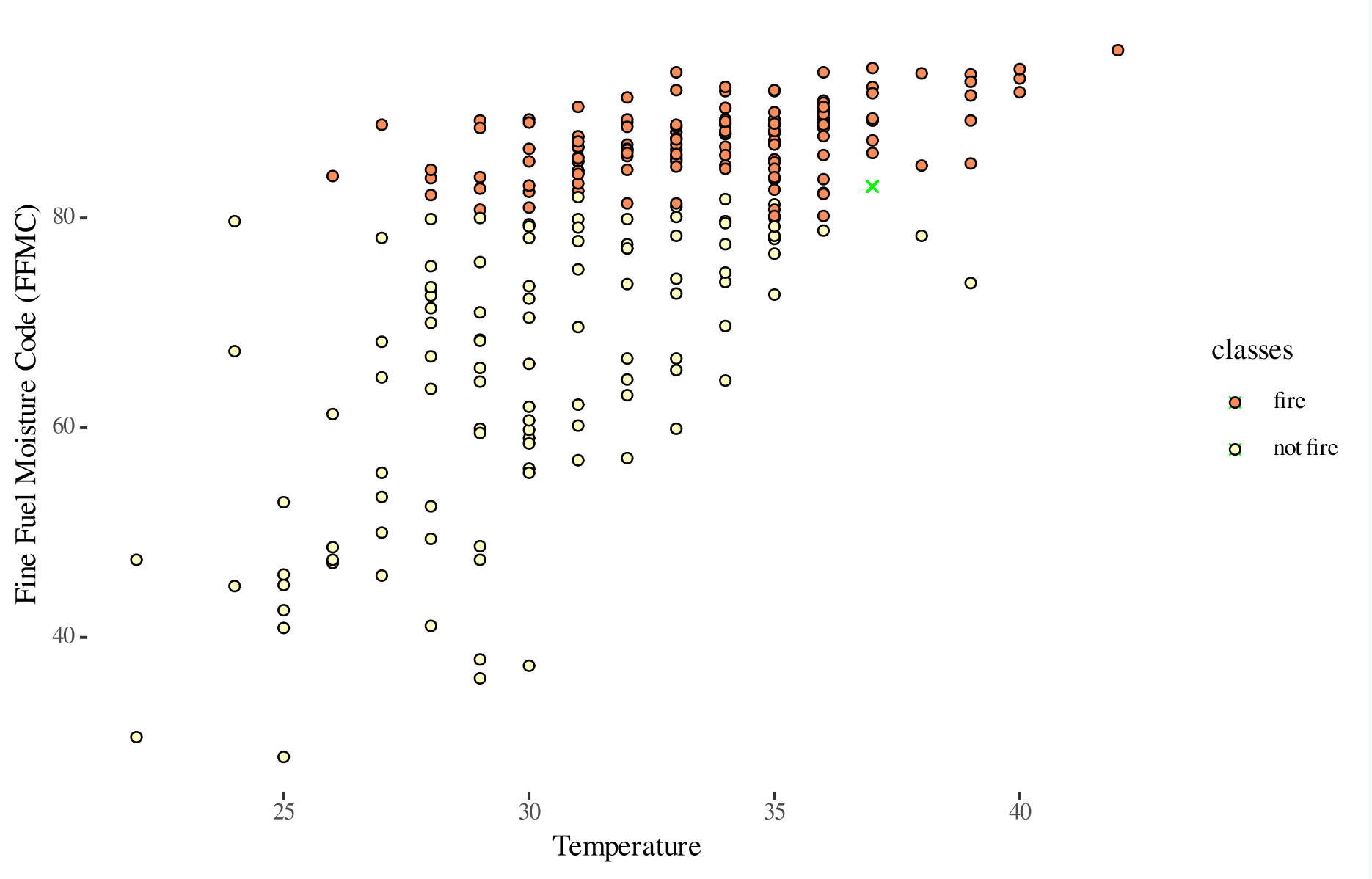
Glimpse of the data

```
glimpse(fire)
Rows: 243
Columns: 12
$ date        <dttm> 2012-06-01, 2012-06-02, 2012-06-03, 2012-06-04, 2012-06-0…
$ temperature <dbl> 29, 29, 26, 25, 27, 31, 33, 30, 25, 28, 31, 26, 27, 30, 28…
$ rh          <dbl> 57, 61, 82, 89, 77, 67, 54, 73, 88, 79, 65, 81, 84, 78, 80…
$ ws          <dbl> 18, 13, 22, 13, 16, 14, 13, 15, 13, 12, 14, 19, 21, 20, 17…
$ rain        <dbl> 0.0, 1.3, 13.1, 2.5, 0.0, 0.0, 0.0, 0.0, 0.2, 0.0, 0.0, 0.…
$ ffmc        <dbl> 65.7, 64.4, 47.1, 28.6, 64.8, 82.6, 88.2, 86.6, 52.9, 73.2…
$ dmc         <dbl> 3.4, 4.1, 2.5, 1.3, 3.0, 5.8, 9.9, 12.1, 7.9, 9.5, 12.5, 1…
$ dc          <dbl> 7.6, 7.6, 7.1, 6.9, 14.2, 22.2, 30.5, 38.3, 38.8, 46.3, 54…
$ isi         <dbl> 1.3, 1.0, 0.3, 0.0, 1.2, 3.1, 6.4, 5.6, 0.4, 1.3, 4.0, 4.8…
$ bui         <dbl> 3.4, 3.9, 2.7, 1.7, 3.9, 7.0, 10.9, 13.5, 10.5, 12.6, 15.8…
$ fwi         <dbl> 0.5, 0.4, 0.1, 0.0, 0.5, 2.5, 7.2, 7.1, 0.3, 0.9, 5.6, 7.1…
$ classes     <chr> "not fire", "not fire", "not fire", "not fire", "not fire"…
```

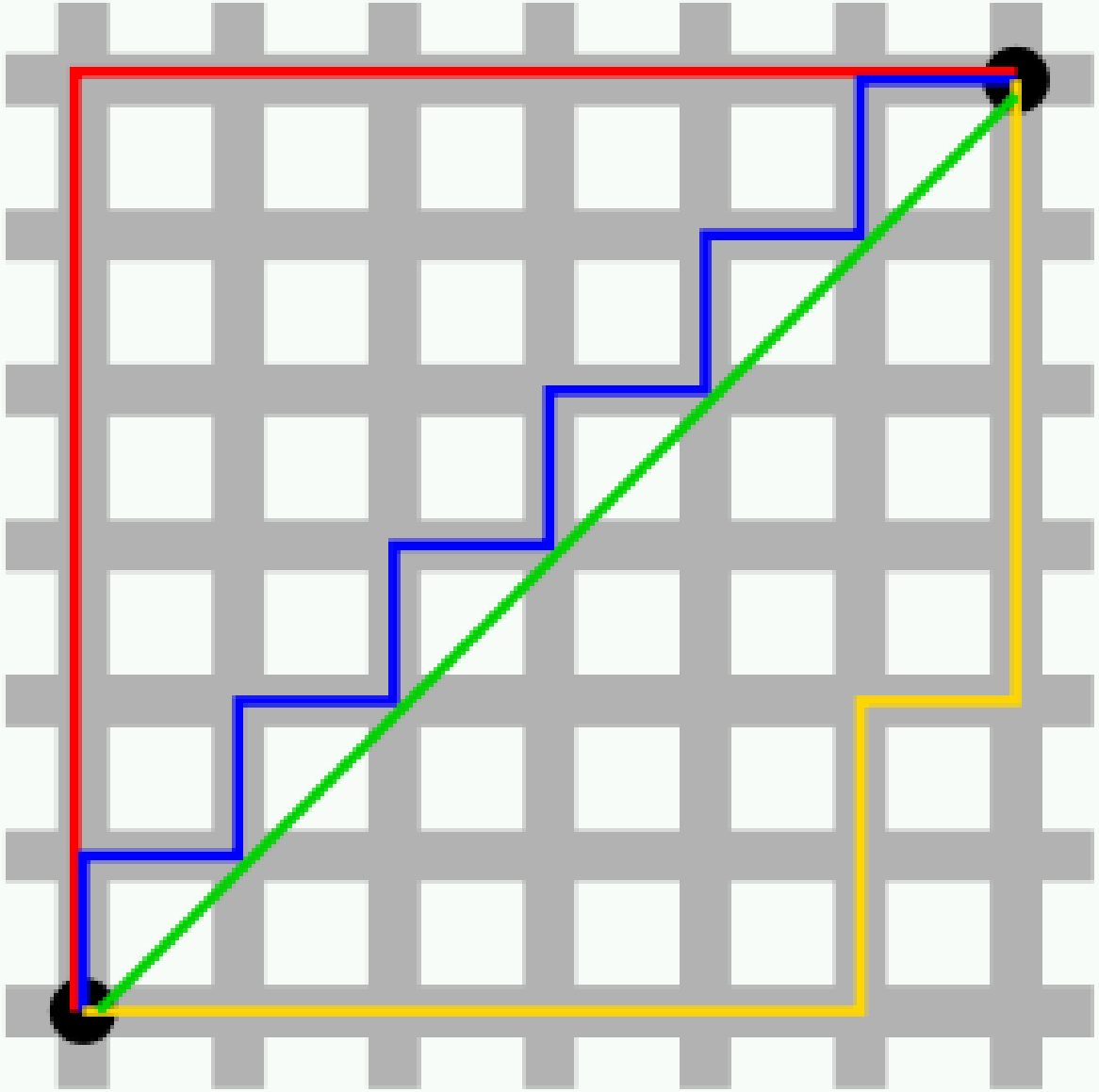
Scatterplot



How can we classify a new observation?



Calculating distance



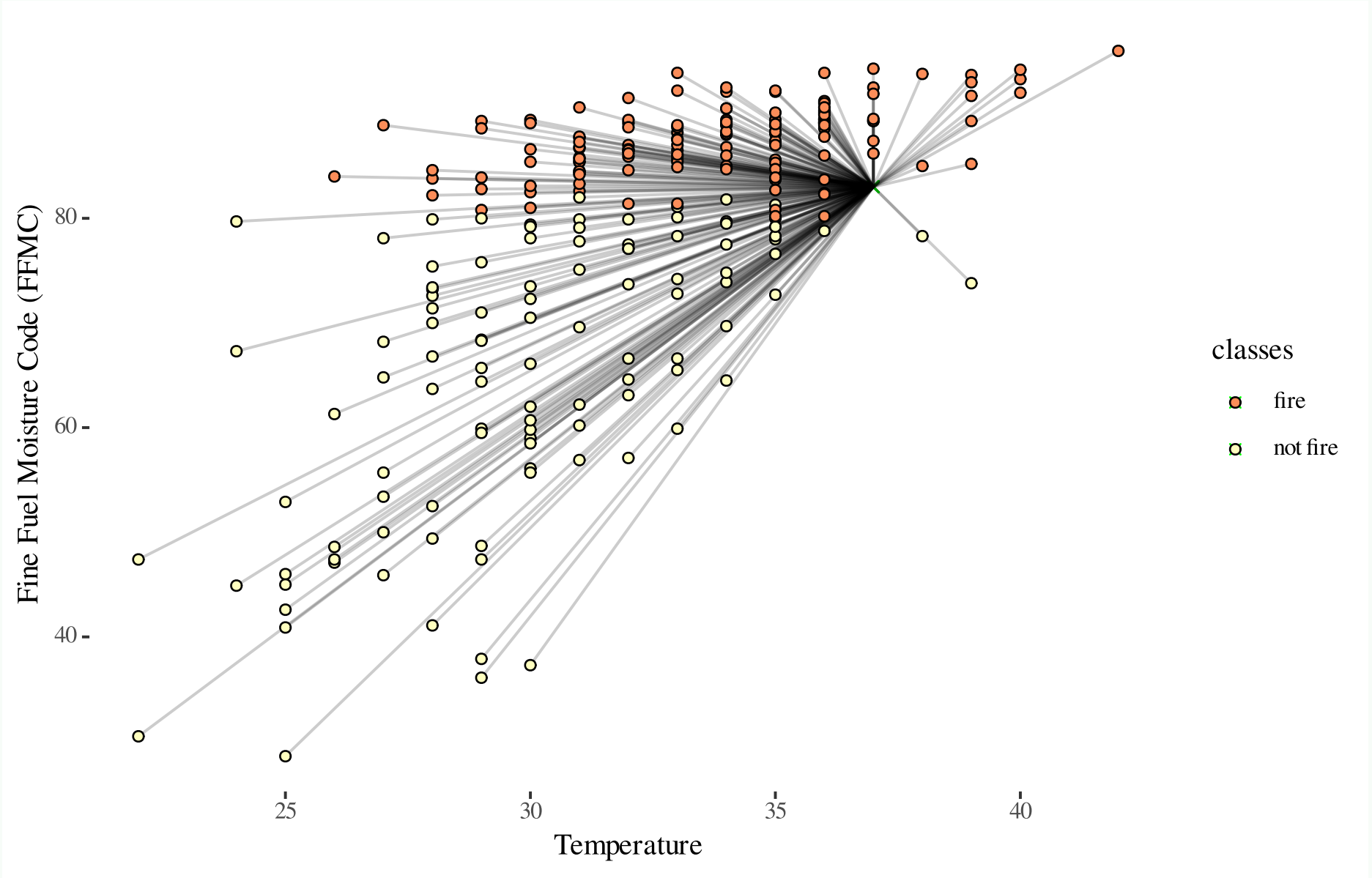
Euclidean distance: the straight line distance between two points on the x-y plane with coordinates (x_a, y_a) and (x_b, y_b)

$$\text{Distance} = \sqrt{(x_a - x_b)^2 + (y_a - y_b)^2}$$

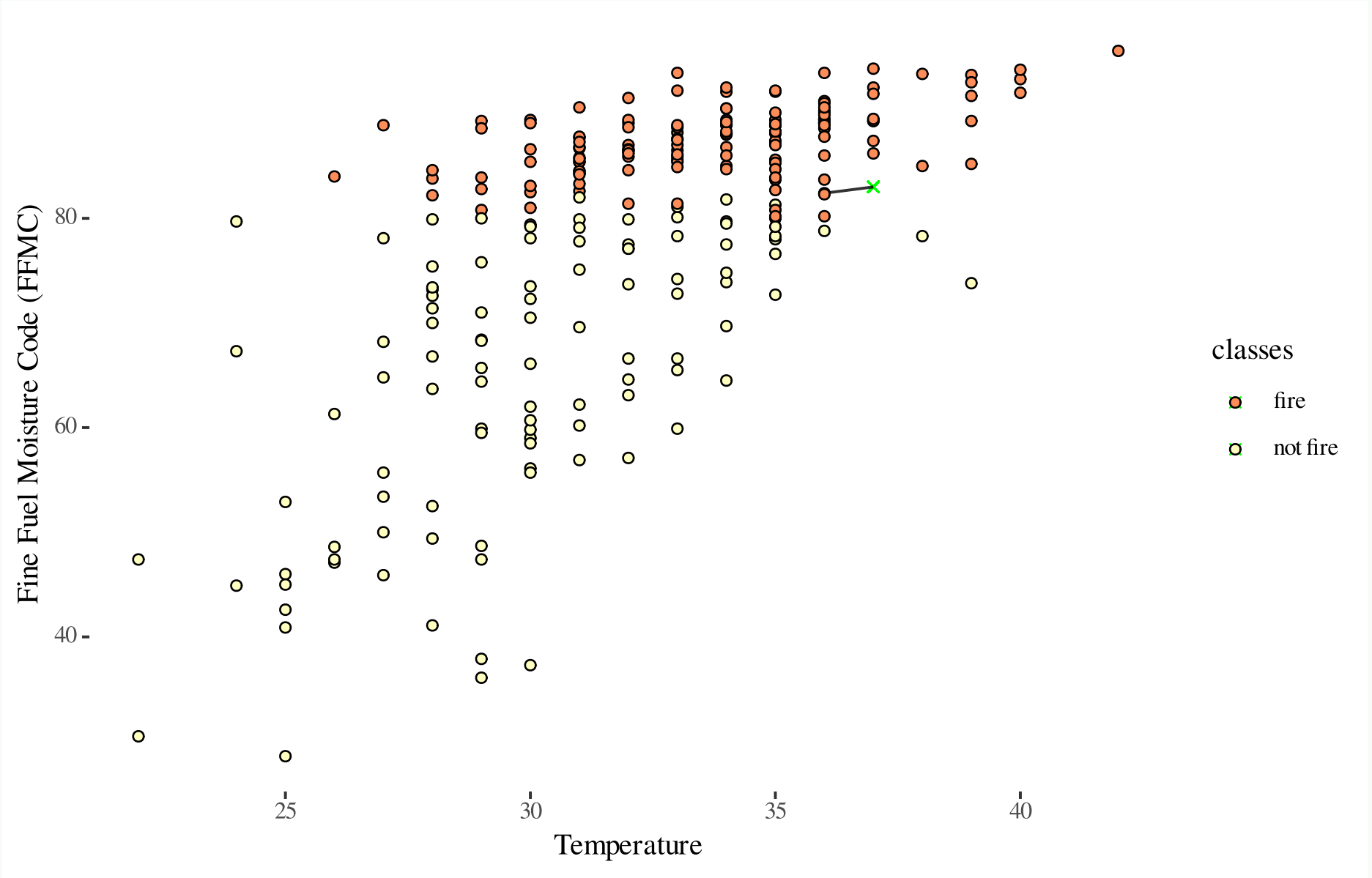
Manhattan distance: the "taxi-cab" distance between two points on the x-y plane

$$\text{Distance} = |x_a - x_b| + |y_a - y_b|$$

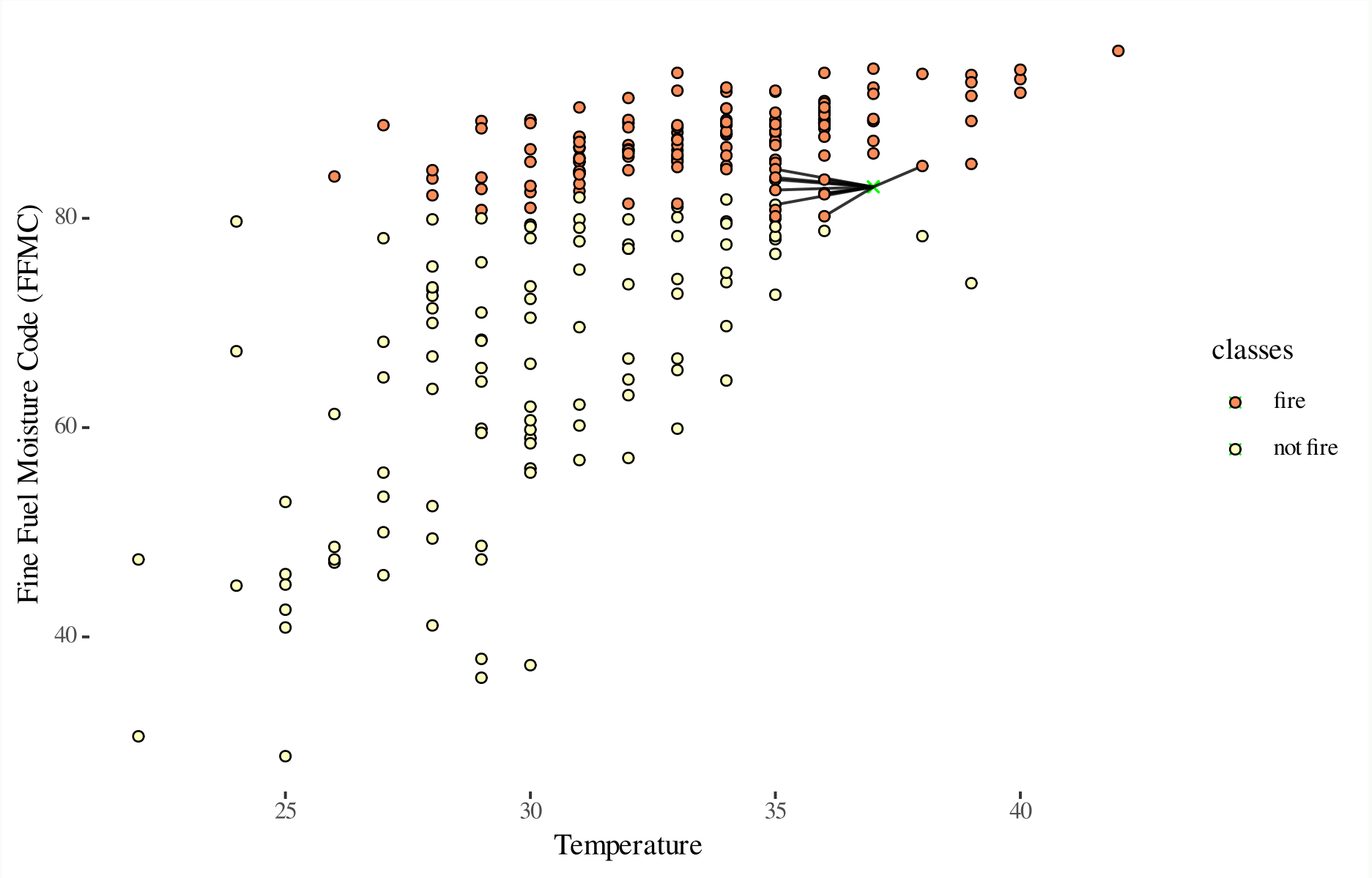
Looking at Euclidean distance



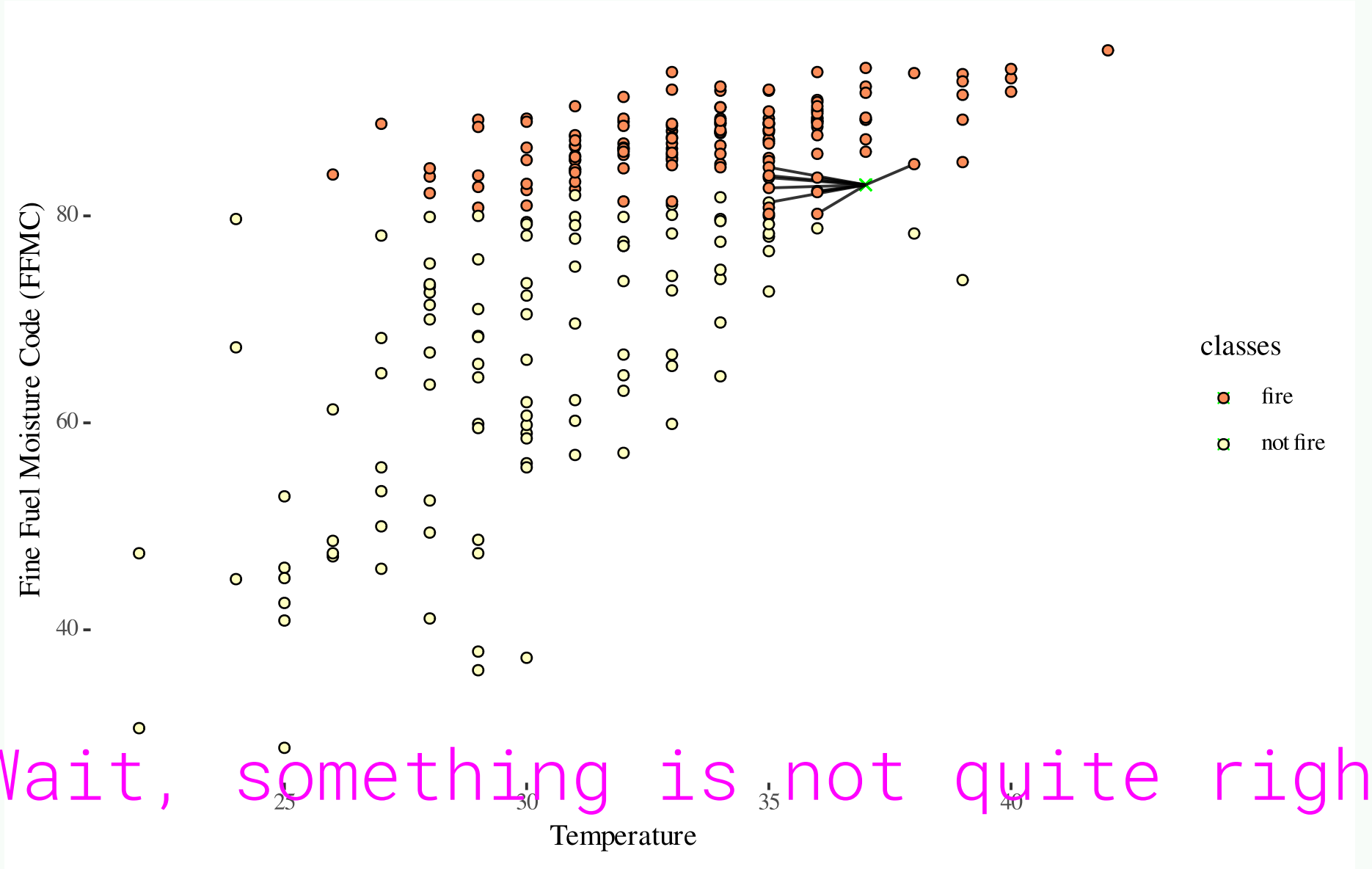
1-Nearest Neighbor (NN)



10-NN


Fine Fuel Moisture Code (FFMC)
80
60
40
25
30
35
40
Temperature
classes
fire
not fire

10-NN



Wait, something is not quite right..

Need to standardize data

```
standardize <- function(x, na.rm = FALSE) {
  (x - mean(x, na.rm = na.rm)) /
    sd(x, na.rm = na.rm)
}
```

```
fire %>% select(ffmc, temperature,) %>%
  map_df(.f = ~sd(.))
# A tibble: 1 × 2
   ffmc temperature
  <dbl>       <dbl>
1  14.3        3.63
```

- Predictors with **larger variation** will have larger influence on which cases are "nearest" neighbors
- Methods relying on distance can be **sensitive (i.e. not invariant)** to the scale of the predictors
- **Standardizing** only shifts and rescales the variable, it doesn't change the shape of the distribution

dplyr::across()

use within **mutate()** or **summarize()** to apply function(s) to a **selection** *of* **columns!**

EXAMPLE:

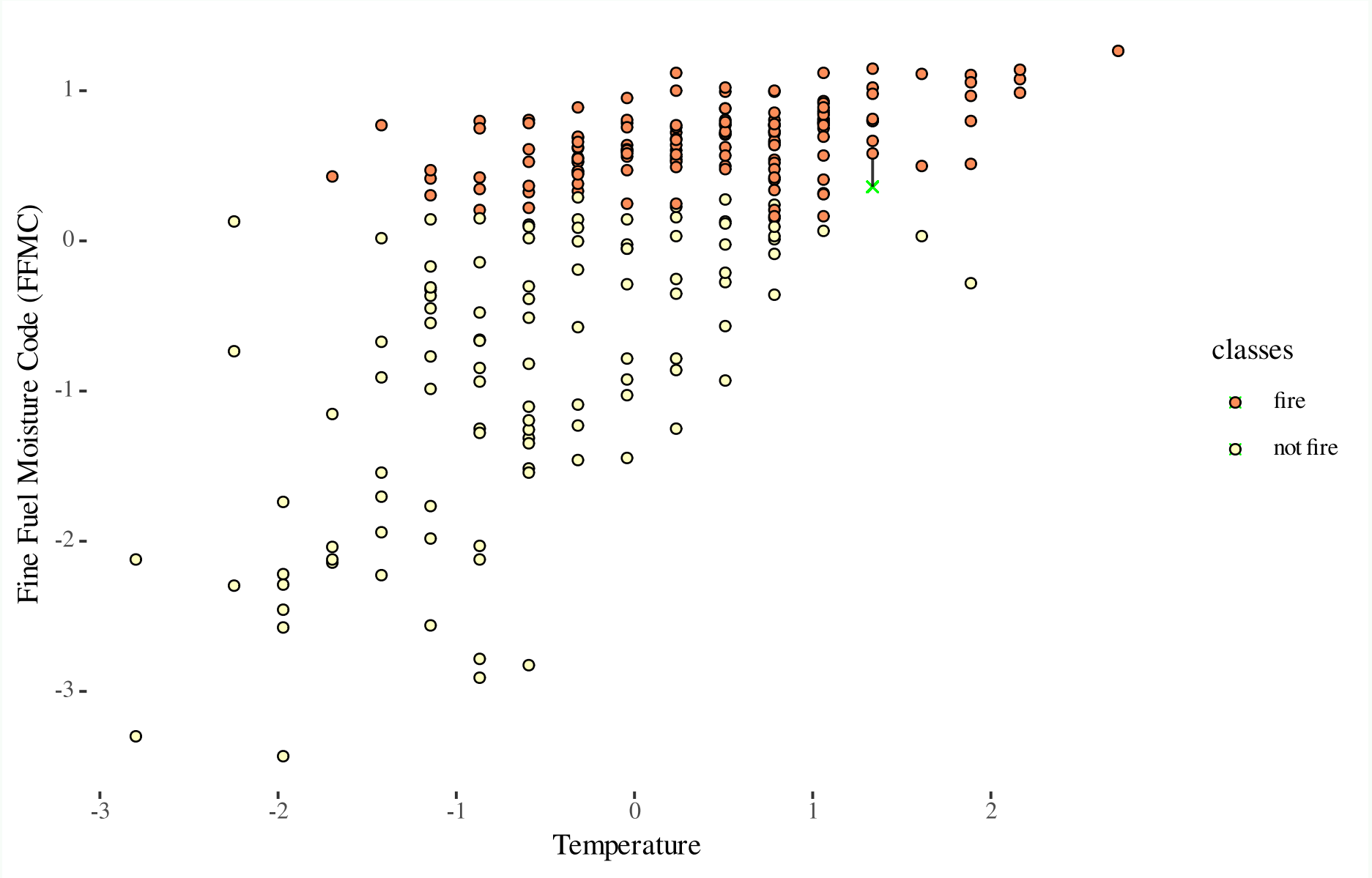
```
df %>%
group_by(species) %>%
summarize(
  across(where(is.numeric), mean)
)
```

species	mass_g	age_yr	range_sqmi
pika	163	2.4	0.46
marmot	1509	3.0	0.87
marmot	2417	5.6	0.62

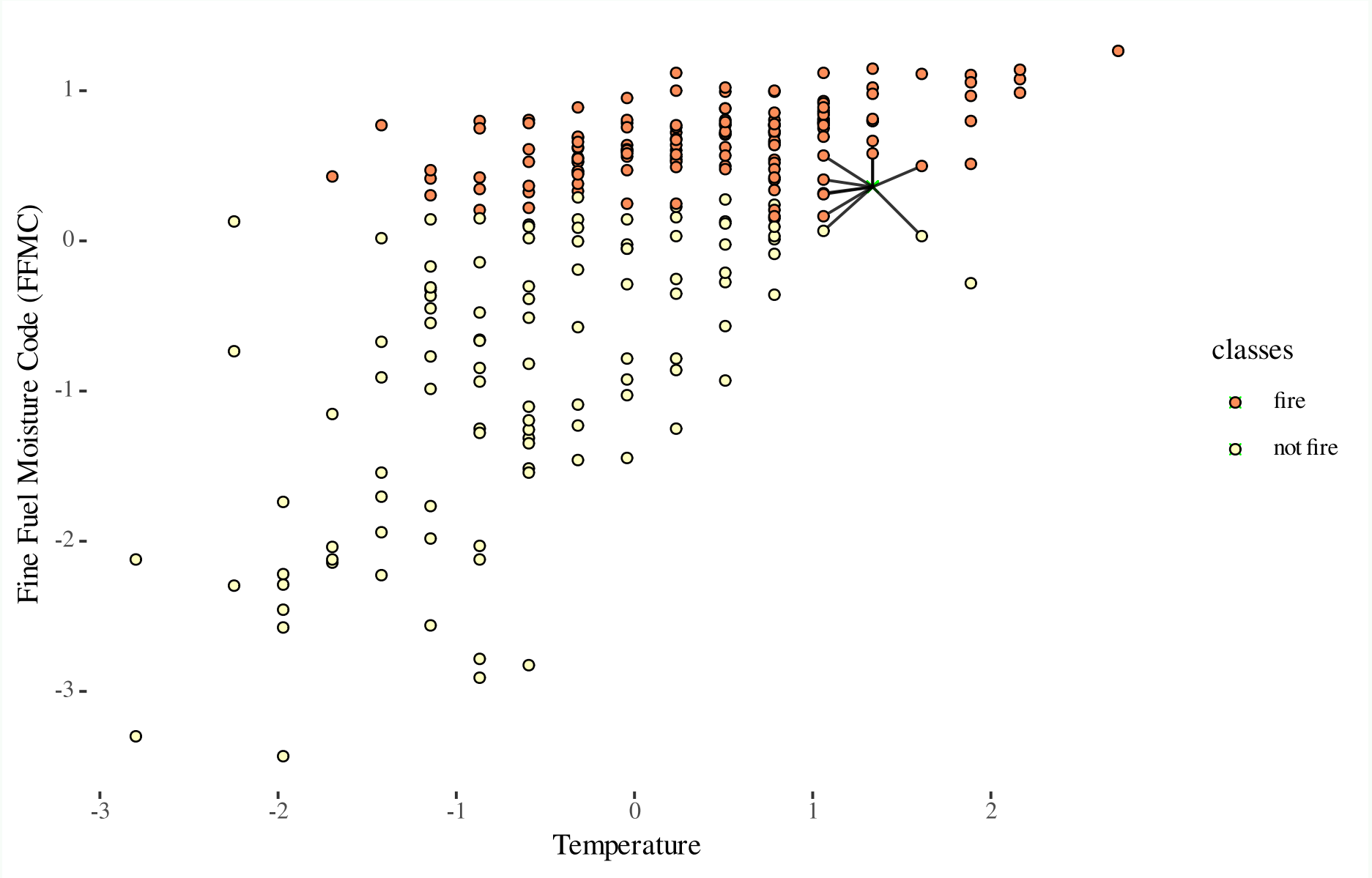
Standardized data

```
fire1 <- fire %>% mutate(across(where(is.numeric), standardize))
fire1 %>% summary()
      date                          temperature            rh          
 Min.   :2012-06-01 00:00:00.00   Min.   :-2.79828   Min.   :-2.76778  
 1st Qu.:2012-07-01 00:00:00.00   1st Qu.:-0.59323   1st Qu.:-0.64345  
 Median :2012-08-01 00:00:00.00   Median :-0.04197   Median : 0.06466  
 Mean   :2012-07-31 13:43:42.22   Mean   : 0.00000   Mean   : 0.00000  
 3rd Qu.:2012-08-31 00:00:00.00   3rd Qu.: 0.78492   3rd Qu.: 0.77278  
 Max.   :2012-09-30 00:00:00.00   Max.   : 2.71434   Max.   : 1.88552  
       ws                 rain                ffmc                dmc         
 Min.   :-3.3769   Min.   :-0.3809   Min.   :-3.4316   Min.   :-1.1281  
 1st Qu.:-0.5313   1st Qu.:-0.3809   1st Qu.:-0.4176   1st Qu.:-0.7166  
 Median :-0.1757   Median :-0.3809   Median : 0.3803   Median :-0.2728  
 Mean   : 0.0000   Mean   : 0.0000   Mean   : 0.0000   Mean   : 0.0000  
 3rd Qu.: 0.5357   3rd Qu.:-0.1313   3rd Qu.: 0.7288   3rd Qu.: 0.4938  
 Max.   : 4.8041   Max.   : 8.0057   Max.   : 1.2654   Max.   : 4.1329  
       dc                 isi                 bui                 fwi         
 Min.   :-0.8923   Min.   :-1.1416   Min.   :-1.0957   Min.   :-0.9455  
 1st Qu.:-0.7779   1st Qu.:-0.8046   1st Qu.:-0.7514   1st Qu.:-0.8515  
 Median :-0.3426   Median :-0.2991   Median :-0.3015   Median :-0.3811  
 Mean   : 0.0000   Mean   : 0.0000   Mean   : 0.0000   Mean   : 0.0000  
 3rd Qu.: 0.4126   3rd Qu.: 0.6036   3rd Qu.: 0.4188   3rd Qu.: 0.5933  
 Max.   : 3.5868   Max.   : 3.4321   Max.   : 3.6061   Max.   : 3.2342  
   classes         
 Length:243         
 Class :character   
 Mode  :character   
```

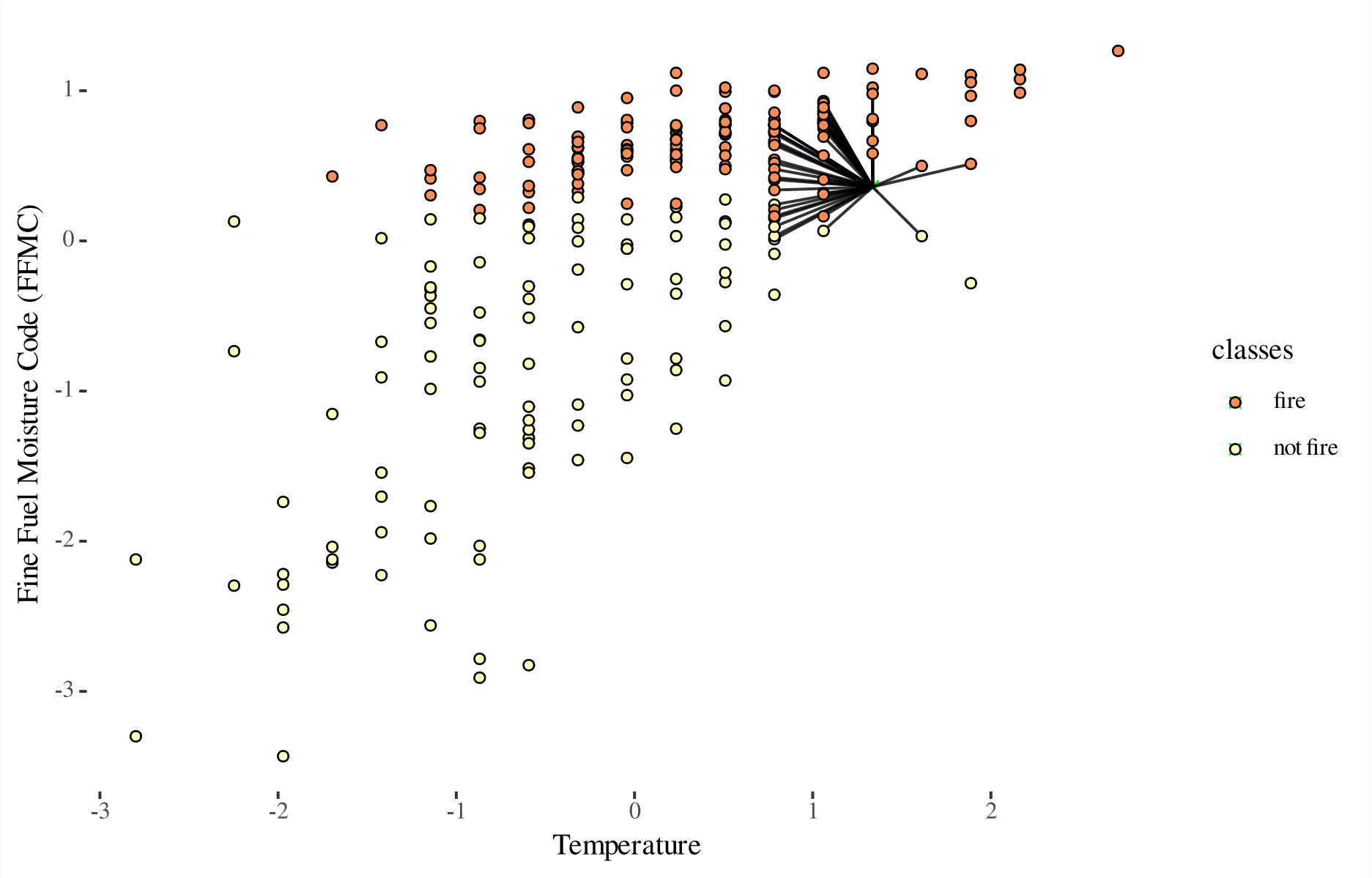
1-NN again


Fine Fuel Moisture Code (FFMC)
1
0
-1
-2
-3
-3
-2
-1
0
1
2
Temperature
classes
fire
not fire

10-NN again


Fine Fuel Moisture Code (FFMC)
1
0
-1
-2
-3
-3
-2
-1
0
1
2
Temperature
classes
fire
not fire

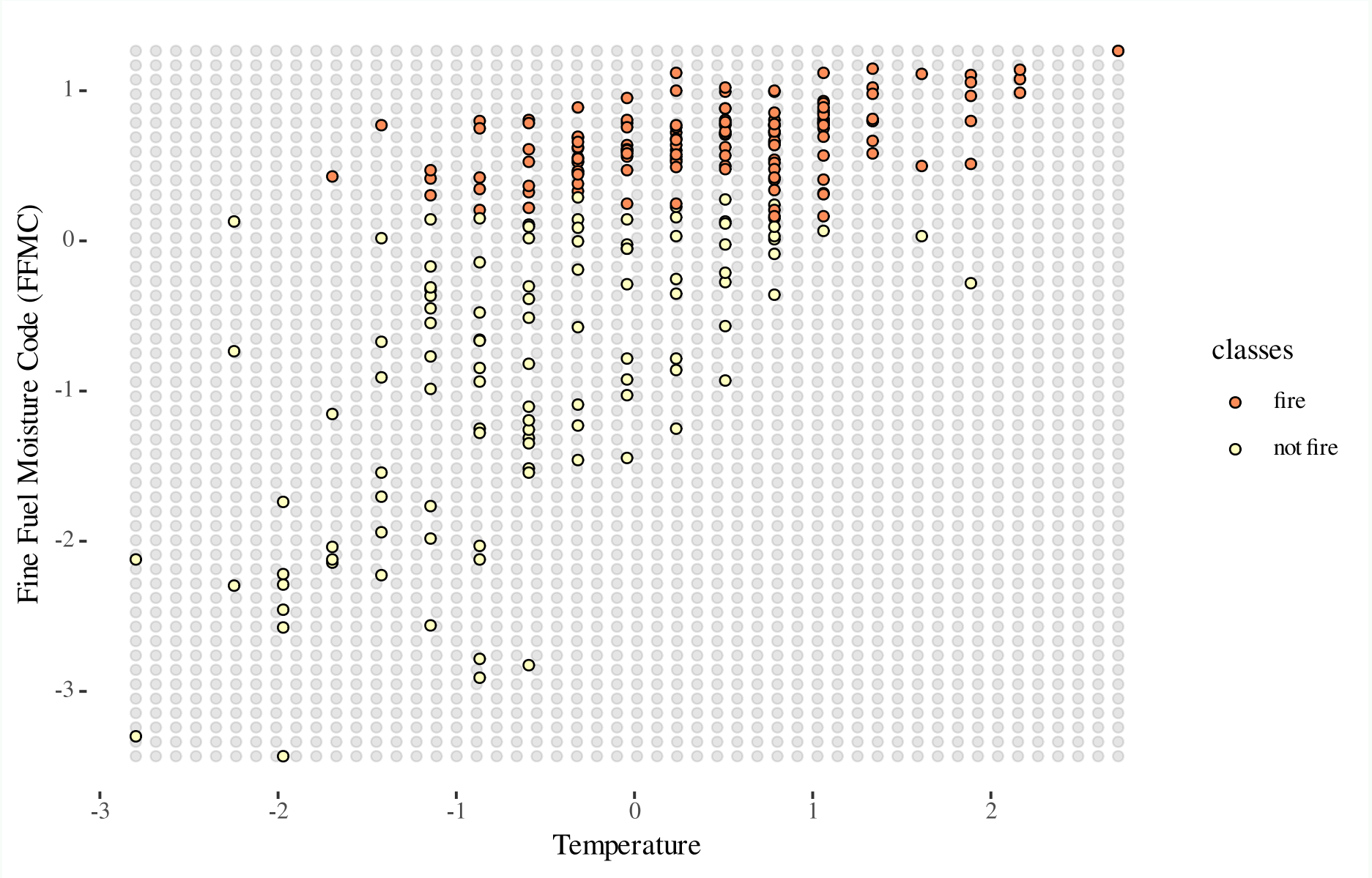
50-NN again


Fine Fuel Moisture Code (FFMC)
1
0
-1
-2
-3
-3
-2
-1
0
1
2
Temperature
classes
fire
not fire

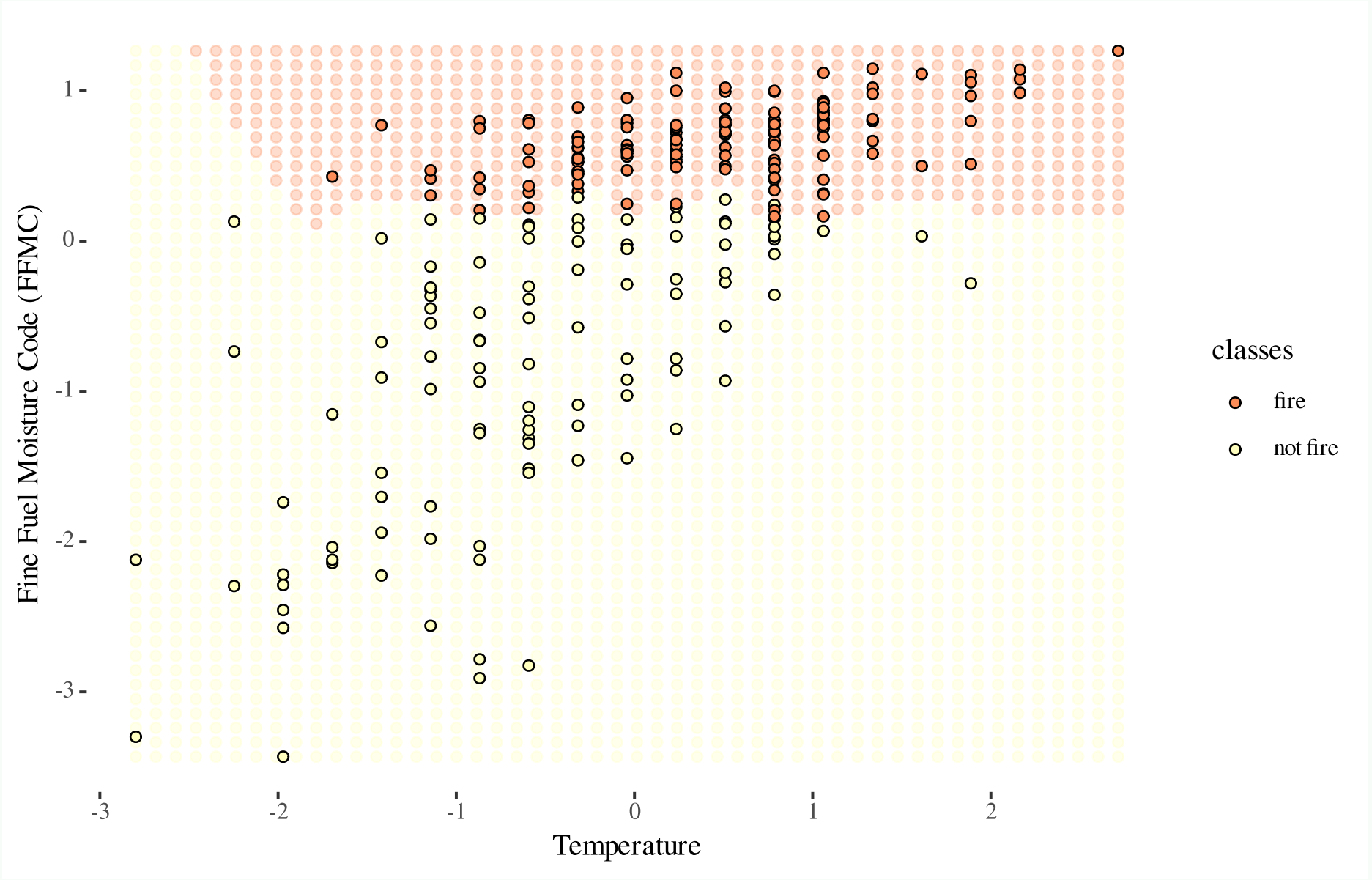
Visualizing the decision boundary

- We can map out the region in feature-space where the classifier would predict 'fire', and the kinds where it would predict 'not fire'
- There is some boundary between the two, where points on one side of the boundary will be classified 'fire' and points on the other side will be classified 'not fire'
- This boundary is called **decision boundary**

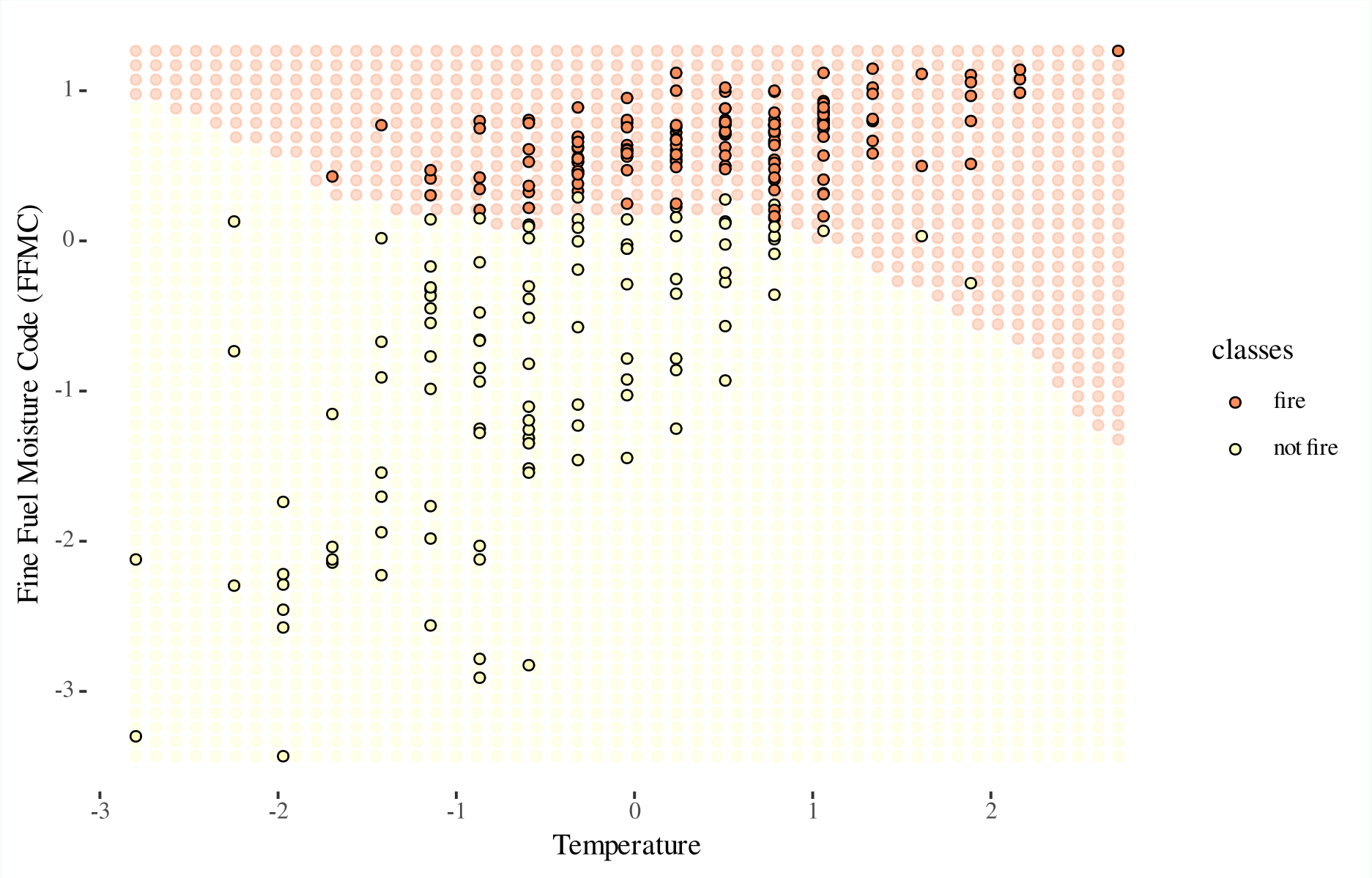
Visualizing the decision boundary

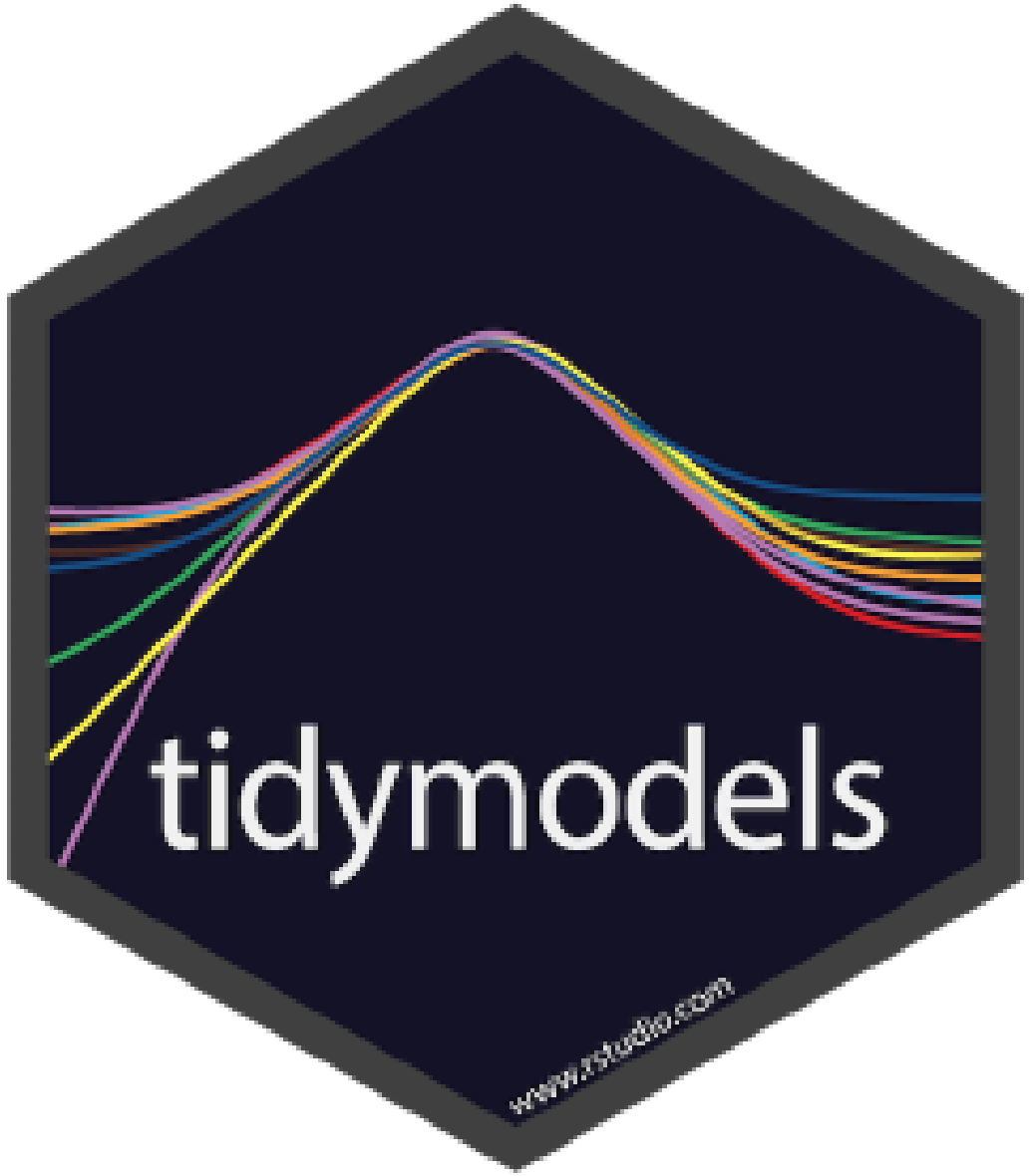


1-NN decision boundary



25-NN decision boundary





a collection of packages for modeling and machine learning using tidyverse principles

1. Load data and convert to correct data types

```
fire_raw <- read_csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/Algeriafires.csv") %>%
  janitor::clean_names() %>% tidyr::drop_na() %>%
  mutate(classes = as_factor(classes)) %>%
  mutate_at(c(10,13), as.numeric) %>%
  select(temperature, ffmc, classes)
```

```
head(fire_raw)
# A tibble: 6 × 3
  temperature  ffmc classes
        <dbl> <dbl> <fct>
1          29  65.7 not fire
2          29  64.4 not fire
3          26  47.1 not fire
4          25  28.6 not fire
5          27  64.8 not fire
6          31  82.6 fire
```

2. Create a recipe for data preprocessing

```
fire_recipe <- recipe(classes ~ ., data = fire_raw) %>%
 step_scale(all_predictors()) %>%
 step_center(all_predictors()) %>%
 prep()
```

3. Apply the recipe to the data set

```
fire_scaled <- bake(fire_recipe, fire_raw)
```

```
# A tibble: 243 × 3
   temperature    ffmc classes
         <dbl>   <dbl> <fct>
 1      -0.869 -0.846 not fire
 2      -0.869 -0.937 not fire
 3      -1.70  -2.14  not fire
 4      -1.97  -3.43  not fire
 5      -1.42  -0.909 not fire
 6      -0.318  0.332 fire
 7       0.234  0.722 fire
 8      -0.593  0.610 fire
 9      -1.97  -1.74  not fire
10      -1.14  -0.324 not fire
# … with 233 more rows
```

4. Create a model specification

```
knn_spec <- nearest_neighbor(mode = "classification",
                             engine = "kknn",
                             weight_func = "rectangular",
                             neighbors = 5)
```

5. Fit the model on the preprocessed data

```
knn_fit <- knn_spec %>%
 fit(classes ~ ., data = fire_scaled)
```

6. Classify

Suppose we get two new observations, use predict to classify the observations

```
# Data frame/tibble of new observations
new_observations <- tibble(temperature = c(1, 2), ffmc = c(-1, 1))
```

```
# Making classifications (i.e. predictions)
predict(knn_fit, new_data = new_observations)
# A tibble: 2 × 1
  .pred_class
  <fct>
1 not fire
2 fire
```

Further Practice: Pima Indians Diabetes

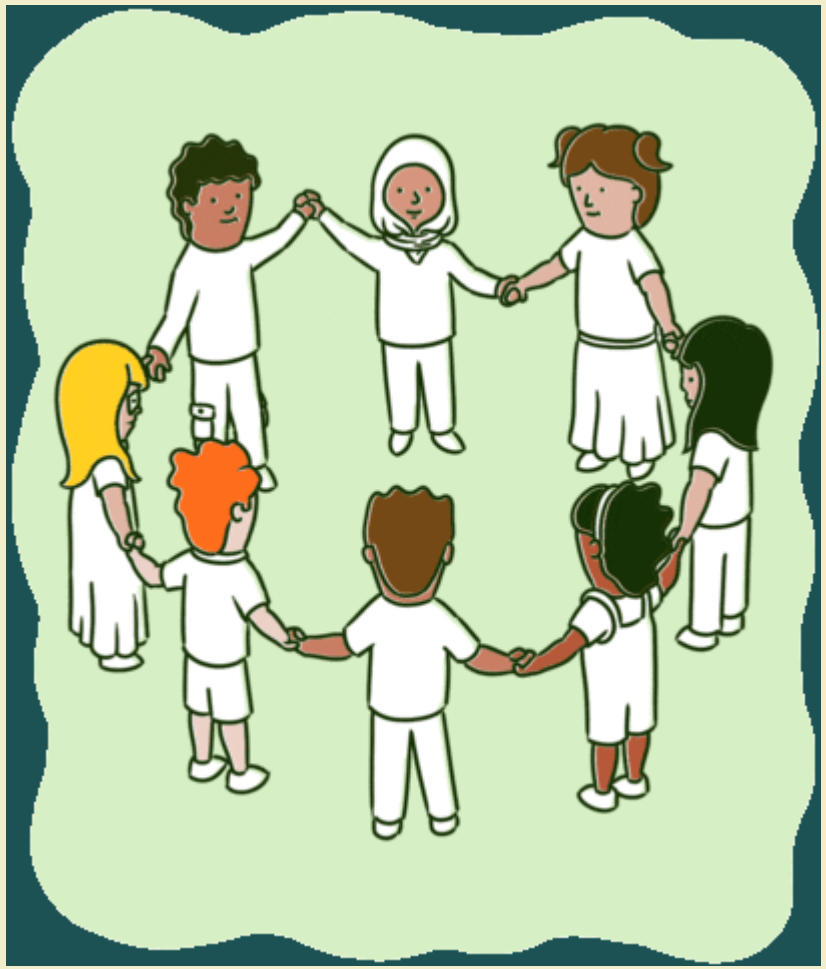
- *Owned by the National Institute of Diabetes and Digestive and Kidney Diseases*
- *A data frame with 768 observations on 9 variables.*
- *We have the lab results of 158 patients, including whether they have CKD*
- *Response variable: diabetes = pos, neg*
- *Predictor variables: pregnant, glucose, pressure, triceps, insulin, mass, pedigree, age*

Variables

Variable	Description
pregnant	Number of times pregnant
glucose	Plasma glucose concentration (glucose tolerance test)
pressure	Diastolic blood pressure (mm Hg)
triceps	Triceps skinfold thickness (mm)
insulin	2-Hour serum insulin (mu U/ml)
mass	Body mass index (weight in kg/(height in m)\²)
pedigree	Diabetes pedigree function
age	Age (years)
diabetes	diabetes case (pos/neg)

GROUP ACTIVITY 1

10:00



- *Let's go over to maize server/ local Rstudio and our class moodle*
- *Get the class activity 21.Rmd file*
- *Work on activity 1*
- *Ask me questions*