STA5092Z EDA Lecture 5-6

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Checking your data - Checklist

- Formulate your question
- Check your data
- Automate your project workflow

We will go through these using the Boston, Ames, World Happiness Datasets. Before moving on, we will look at the code chunk options:

- `echo`: Show (TRUE) or hide (FALSE) the source code in output,
- `eval`: Execute (TRUE) or skip (FALSE) the code,
- `include`: Include both code and output in the rendered document (FALSE hides both),
- `warning`: Show (TRUE) or suppress (FALSE) warnings,
- `message`: Show (TRUE) or suppress (FALSE) messages,
- `results`: “markup” (default), “asis”, “hide”, “hold”. Controls how results are displayed,
- `cache`: Cache results for faster re-rendering,
- `error`: Show errors in output (TRUE) or stop rendering (FALSE).

Libraries

`pacman::p_load()` loads packages and installs missing ones. This is convenient for now, but in production/reproducible work you might want a fixed `renv` environment instead. See: renv

```
if (!require("pacman")) install.packages("pacman")
pacman::p_load(here, data.table, purrrlyr, reshape2,
               tidyverse,  flextable, SmartEDA, DataExplorer, DT,
               inspectdf, lubridate, janitor, forcats,
               fastDummies, units, tsibble, feasts, fable,
               tmap, tmaptools, mapdeck, leaflet, leafgl,
               rgeoda, osmdata,
               exactextractr, hereR, ggmap,
               kableExtra, knitr,
               colourvalues, viridis,
               readxl, ggfortify, gganimate,
               grateful)
```

Ames Dataset

This problem presents a data set describing the sale of individual residential property in Ames, Iowa from 2006 to 2010. The data set contains 1460 observations and a large number of explanatory variables (nominal, ordinal, discrete, and continuous) involved in assessing home values. With 79 explanatory variables describing (almost) every aspect of residential homes in Ames, Iowa, this Kaggle competition challenges you to predict the final price of each home. The full dataset as provided on the Kaggle website has been provided on Vula in the file ames.csv or in the following link:

Kaggle AMES competition

1) Load the data + quick missingness summary (variable-level)

```
ames <- read.csv(here::here("Datasets", "Ames", "ames.csv"))
library(naniar)
```

```
Warning: package 'naniar' was built under R version 4.4.3
```

```
Attaching package: 'naniar'
```

```
The following object is masked from 'package:tsibble':

    pedestrian
```

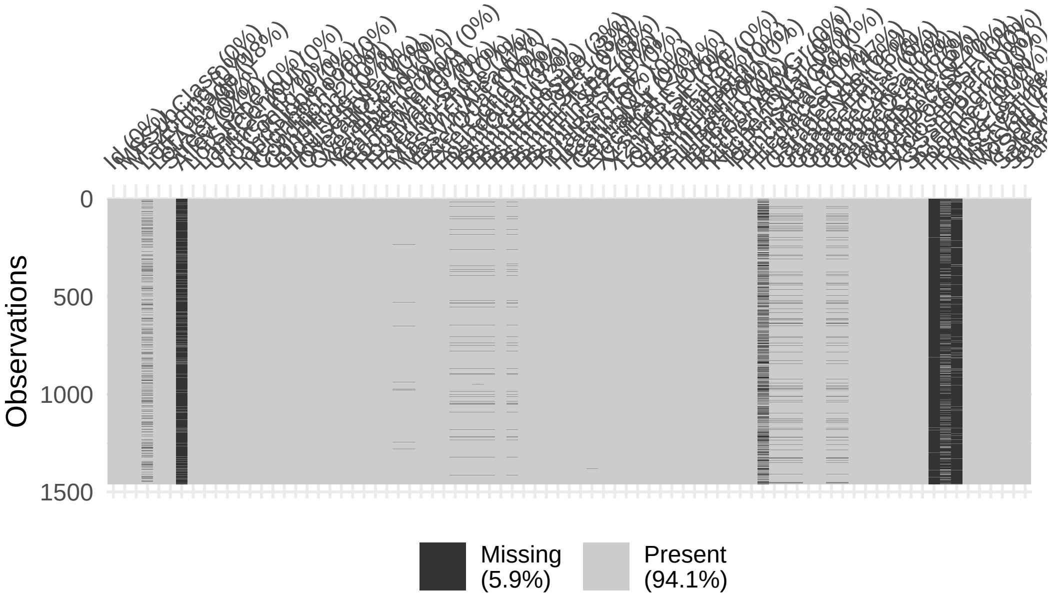
```
ames |>
  miss_var_summary()
```

```
# A tibble: 81 x 3
   variable     n_miss pct_miss
   <chr>         <int>    <num>
 1 PoolQC         1453    99.5
 2 MiscFeature    1406    96.3
 3 Alley          1369    93.8
 4 Fence          1179    80.8
 5 FireplaceQu     690    47.3
 6 LotFrontage     259    17.7
 7 GarageType       81     5.55
 8 GarageYrBlt      81     5.55
 9 GarageFinish     81     5.55
10 GarageQual       81     5.55
# i 71 more rows
```

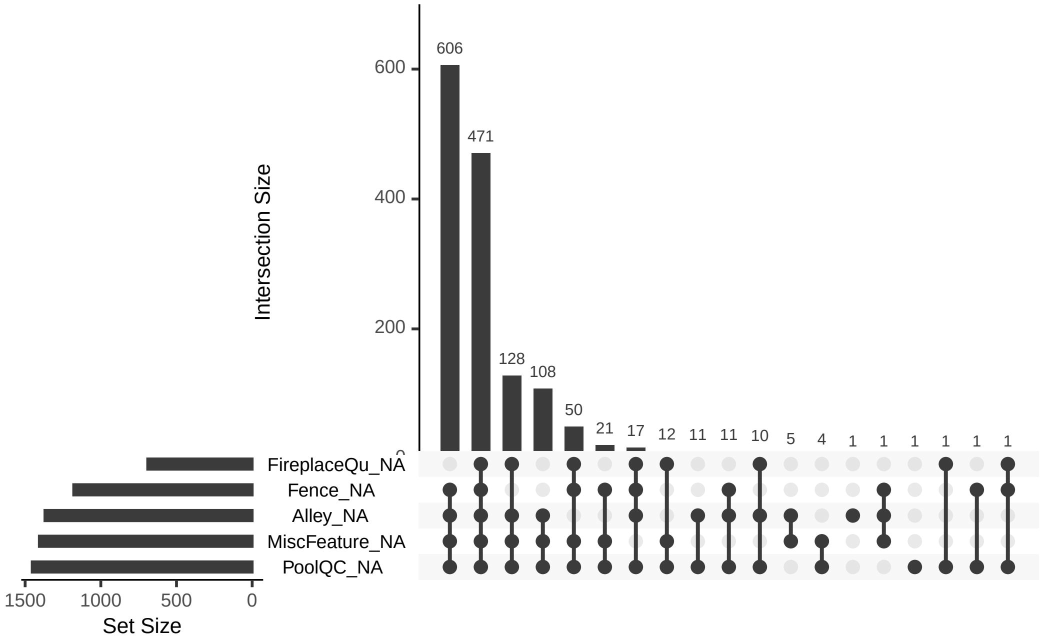
Here we should look for variables with very high percentage missingness which may need special handling (drop, impute, or treat missing as meaningful). Identify patterns like "structural missingness" (e.g., PoolArea missing because most houses have no pool).

2) Visualize missingness patterns (row-level + structure)

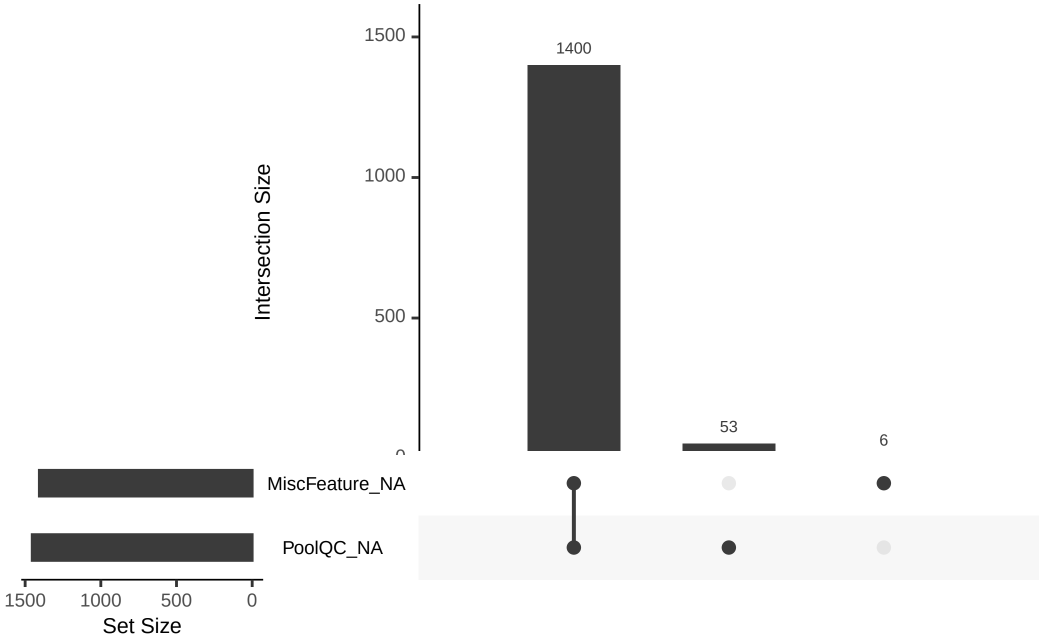
```
vis_miss(ames)
```



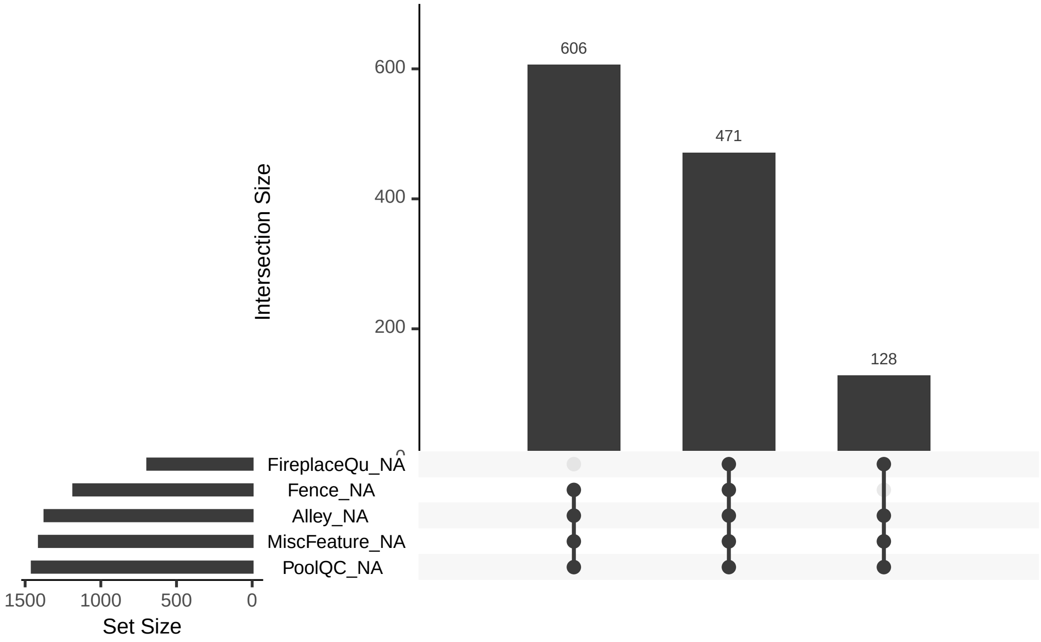
```r
gg_miss_upset(ames)
```



```r
gg_miss_upset(ames, nsets=2) #nsets comparing the top missing two sets
```



```r
gg_miss_upset(ames, nintersects=3) #nsets, nintersects are some useful options.
```



If a few variables dominate missingness, you can focus cleaning there. If certain variables always go missing together, it might indicate a data collection rule.

3) SmartEDA: automated overview tables

Are the variable types correct? Are there "coded" missing values (like 0 or 999) that aren't NA?

```
library(SmartEDA)
summarytable = ExpData(data = ames, type = 2)
summarytable
```

```
   Index Variable_Name Variable_Type Sample_n Missing_Count Per_of_Missing
1      1            Id       integer     1460             0          0.000
2      2    MSSubClass       integer     1460             0          0.000
3      3      MSZoning     character     1460             0          0.000
4      4   LotFrontage       integer     1201           259          0.177
5      5       LotArea       integer     1460             0          0.000
6      6        Street     character     1460             0          0.000
7      7         Alley     character       91          1369          0.938
8      8      LotShape     character     1460             0          0.000
9      9   LandContour     character     1460             0          0.000
10    10     Utilities     character     1460             0          0.000
11    11     LotConfig     character     1460             0          0.000
12    12     LandSlope     character     1460             0          0.000
13    13  Neighborhood     character     1460             0          0.000
14    14    Condition1     character     1460             0          0.000
15    15    Condition2     character     1460             0          0.000
16    16      BldgType     character     1460             0          0.000
17    17    HouseStyle     character     1460             0          0.000
18    18   OverallQual       integer     1460             0          0.000
19    19   OverallCond       integer     1460             0          0.000
20    20     YearBuilt       integer     1460             0          0.000
21    21  YearRemodAdd       integer     1460             0          0.000
22    22     RoofStyle     character     1460             0          0.000
23    23      RoofMatl     character     1460             0          0.000
24    24   Exterior1st     character     1460             0          0.000
25    25   Exterior2nd     character     1460             0          0.000
26    26    MasVnrType     character     1452             8          0.005
27    27    MasVnrArea       integer     1452             8          0.005
28    28     ExterQual     character     1460             0          0.000
29    29     ExterCond     character     1460             0          0.000
```

```
30    30    Foundation    character    1460          0        0.000
31    31      BsmtQual    character    1423         37        0.025
32    32      BsmtCond    character    1423         37        0.025
33    33  BsmtExposure    character    1422         38        0.026
34    34  BsmtFinType1    character    1423         37        0.025
35    35    BsmtFinSF1      integer    1460          0        0.000
36    36  BsmtFinType2    character    1422         38        0.026
37    37    BsmtFinSF2      integer    1460          0        0.000
38    38     BsmtUnfSF      integer    1460          0        0.000
39    39   TotalBsmtSF      integer    1460          0        0.000
40    40       Heating    character    1460          0        0.000
41    41     HeatingQC    character    1460          0        0.000
42    42    CentralAir    character    1460          0        0.000
43    43    Electrical    character    1459          1        0.001
44    44     X1stFlrSF      integer    1460          0        0.000
45    45     X2ndFlrSF      integer    1460          0        0.000
46    46  LowQualFinSF      integer    1460          0        0.000
47    47     GrLivArea      integer    1460          0        0.000
48    48  BsmtFullBath      integer    1460          0        0.000
49    49  BsmtHalfBath      integer    1460          0        0.000
50    50      FullBath      integer    1460          0        0.000
51    51      HalfBath      integer    1460          0        0.000
52    52  BedroomAbvGr      integer    1460          0        0.000
53    53  KitchenAbvGr      integer    1460          0        0.000
54    54   KitchenQual    character    1460          0        0.000
55    55  TotRmsAbvGrd      integer    1460          0        0.000
56    56    Functional    character    1460          0        0.000
57    57    Fireplaces      integer    1460          0        0.000
58    58   FireplaceQu    character     770        690        0.473
59    59    GarageType    character    1379         81        0.055
60    60   GarageYrBlt      integer    1379         81        0.055
61    61  GarageFinish    character    1379         81        0.055
62    62    GarageCars      integer    1460          0        0.000
63    63    GarageArea      integer    1460          0        0.000
64    64    GarageQual    character    1379         81        0.055
65    65    GarageCond    character    1379         81        0.055
66    66    PavedDrive    character    1460          0        0.000
67    67    WoodDeckSF      integer    1460          0        0.000
68    68   OpenPorchSF      integer    1460          0        0.000
69    69 EnclosedPorch      integer    1460          0        0.000
70    70    X3SsnPorch      integer    1460          0        0.000
71    71   ScreenPorch      integer    1460          0        0.000
72    72      PoolArea      integer    1460          0        0.000
```

```
73    73        PoolQC     character    7            1453          0.995
74    74         Fence     character  281            1179          0.808
75    75   MiscFeature     character   54            1406          0.963
76    76       MiscVal       integer 1460               0          0.000
77    77        MoSold       integer 1460               0          0.000
78    78        YrSold       integer 1460               0          0.000
79    79      SaleType     character 1460               0          0.000
80    80 SaleCondition     character 1460               0          0.000
81    81     SalePrice       integer 1460               0          0.000
   No_of_distinct_values
1                   1460
2                     15
3                      5
4                    110
5                   1073
6                      2
7                      3
8                      4
9                      4
10                     2
11                     5
12                     3
13                    25
14                     9
15                     8
16                     5
17                     8
18                    10
19                     9
20                   112
21                    61
22                     6
23                     8
24                    15
25                    16
26                     5
27                   327
28                     4
29                     5
30                     6
31                     5
32                     5
33                     5
```

34	7
35	637
36	7
37	144
38	780
39	721
40	6
41	5
42	2
43	6
44	753
45	417
46	24
47	861
48	4
49	3
50	4
51	3
52	8
53	4
54	4
55	12
56	7
57	4
58	6
59	7
60	97
61	4
62	5
63	441
64	6
65	6
66	3
67	274
68	202
69	120
70	20
71	76
72	8
73	4
74	5
75	5
76	21

```
77                      12
78                       5
79                       9
80                       6
81                     663
```

4) Exporting summary tables to LaTeX (for reports)

This is especially important to make results “publication-ready”. Helps with controlling formatting rather than pasting screenshots.

```r
library(knitr)
library(kableExtra)
library(magrittr)
```

```


Attaching package: 'magrittr'


The following object is masked from 'package:ggmap':

    inset


The following object is masked from 'package:purrr':

    set_names


The following object is masked from 'package:tidyr':

    extract
```

```r
summarytable |>
    kable(format = 'latex', booktabs = TRUE) |>
    add_header_above(header = c("Text" = 2, "Values" = 2))
```

Text		Values				
Index	Variable_Name	Variable_Type	Sample_n	Missing_Count	Per_of_Missing	No_of_distinct_
1	Id	integer	1460	0	0.000	
2	MSSubClass	integer	1460	0	0.000	
3	MSZoning	character	1460	0	0.000	
4	LotFrontage	integer	1201	259	0.177	
5	LotArea	integer	1460	0	0.000	
6	Street	character	1460	0	0.000	
7	Alley	character	91	1369	0.938	
8	LotShape	character	1460	0	0.000	
9	LandContour	character	1460	0	0.000	
10	Utilities	character	1460	0	0.000	
11	LotConfig	character	1460	0	0.000	
12	LandSlope	character	1460	0	0.000	
13	Neighborhood	character	1460	0	0.000	
14	Condition1	character	1460	0	0.000	
15	Condition2	character	1460	0	0.000	
16	BldgType	character	1460	0	0.000	
17	HouseStyle	character	1460	0	0.000	
18	OverallQual	integer	1460	0	0.000	
19	OverallCond	integer	1460	0	0.000	
20	YearBuilt	integer	1460	0	0.000	
21	YearRemodAdd	integer	1460	0	0.000	
22	RoofStyle	character	1460	0	0.000	
23	RoofMatl	character	1460	0	0.000	
24	Exterior1st	character	1460	0	0.000	
25	Exterior2nd	character	1460	0	0.000	
26	MasVnrType	character	1452	8	0.005	
27	MasVnrArea	integer	1452	8	0.005	
28	ExterQual	character	1460	0	0.000	
29	ExterCond	character	1460	0	0.000	
30	Foundation	character	1460	0	0.000	
31	BsmtQual	character	1423	37	0.025	
32	BsmtCond	character	1423	37	0.025	
33	BsmtExposure	character	1422	38	0.026	
34	BsmtFinType1	character	1423	37	0.025	
35	BsmtFinSF1	integer	1460	0	0.000	
36	BsmtFinType2	character	1422	38	0.026	
37	BsmtFinSF2	integer	1460	0	0.000	
38	BsmtUnfSF	integer	1460	0	0.000	
39	TotalBsmtSF	integer	1460	0	0.000	
40	Heating	character	1460	0	0.000	
41	HeatingQC	character	1460	0	0.000	
42	CentralAir	character	1460	0	0.000	
43	Electrical	character	1459	1	0.001	
44	X1stFlrSF	integer	1460	0	0.000	
45	X2ndFlrSF	integer	1460	0	0.000	
46	LowQualFinSF	integer	1460	0	0.000	
47	GrLivArea	integer	1460	0	0.000	

Or using `flextable()` package to obtain the summary for numerical variables:

```
library(flextable)
ExpNumStat(ames,by="A",gp=NULL,round=2,Nlim=50) |>
  flextable() |>
  autofit() # Summary Table
```

Vname	Group	TN	nNeg	nZero	nPos	NegInf	PosInf	NA_V
BsmtFinSF1	All	1,460	0	467	993	0	0	
BsmtFinSF2	All	1,460	0	1,293	167	0	0	
BsmtUnfSF	All	1,460	0	118	1,342	0	0	
EnclosedPorch	All	1,460	0	1,252	208	0	0	
GarageArea	All	1,460	0	81	1,379	0	0	
GarageYrBlt	All	1,460	0	0	1,379	0	0	
GrLivArea	All	1,460	0	0	1,460	0	0	
Id	All	1,460	0	0	1,460	0	0	
LotArea	All	1,460	0	0	1,460	0	0	
LotFrontage	All	1,460	0	0	1,201	0	0	
MasVnrArea	All	1,460	0	861	591	0	0	
OpenPorchSF	All	1,460	0	656	804	0	0	
SalePrice	All	1,460	0	0	1,460	0	0	
ScreenPorch	All	1,460	0	1,344	116	0	0	
TotalBsmtSF	All	1,460	0	37	1,423	0	0	
WoodDeckSF	All	1,460	0	761	699	0	0	
X1stFlrSF	All	1,460	0	0	1,460	0	0	
X2ndFlrSF	All	1,460	0	829	631	0	0	
YearBuilt	All	1,460	0	0	1,460	0	0	
YearRemodAdd	All	1,460	0	0	1,460	0	0	

5) Numeric summaries with SmartEDA + display with flextable

See what summary information there is available for you. PPeek at column names of the summary output so you can select/format them.

```r
ExpNumStat(ames,by="A",gp=NULL,round=2,Nlim=50) |>
  names()
```

```
 [1] "Vname"          "Group"          "TN"             "nNeg"
 [5] "nZero"          "nPos"           "NegInf"         "PosInf"
 [9] "NA_Value"       "Per_of_Missing" "sum"            "min"
[13] "max"            "mean"           "median"         "SD"
[17] "CV"             "IQR"            "Skewness"       "Kurtosis"
```

Select only a few informative columns (Vname, min, max, CV) and customise header row for readability. You're modelling good communication: don't overwhelm people with 20 columns.

```r
ExpNumStat(ames,by="A",gp=NULL,round=2,Nlim=50) |>
  select(c("Vname","min", "max", "CV")) |>
  flextable() |>
  delete_part(part = "header") |>
  add_header_row(
    values = c("Variable", "Minimum", "Maximum", "Coefficient of Variation")) |>
  bold(part = "header") |>
  align(align = "center", part = "header")|>
  theme_booktabs()
```

Variable	Minimum	Maximum	Coefficient of Variation
BsmtFinSF1	0	5,644	1.03
BsmtFinSF2	0	1,474	3.47
BsmtUnfSF	0	2,336	0.78
EnclosedPorch	0	552	2.78
GarageArea	0	1,418	0.45
GarageYrBlt	1,900	2,010	0.01
GrLivArea	334	5,642	0.35

Variable	Minimum	Maximum	Coefficient of Variation
Id	1	1,460	0.58
LotArea	1,300	215,245	0.95
LotFrontage	21	313	0.35
MasVnrArea	0	1,600	1.75
OpenPorchSF	0	547	1.42
SalePrice	34,900	755,000	0.44
ScreenPorch	0	480	3.70
TotalBsmtSF	0	6,110	0.41
WoodDeckSF	0	857	1.33
X1stFlrSF	334	4,692	0.33
X2ndFlrSF	0	2,065	1.26
YearBuilt	1,872	2,010	0.02
YearRemodAdd	1,950	2,010	0.01

```
  #autofit()
```

6) Summary tables per group (group-aware EDA)

You can have your summary tables per group. Some EDA questions are conditional: e.g., “Do houses with different heating types have different distributions for some numeric variable?”

You need to decide to use `Group` based on which variable? Are group differences meaningful, or just noise? Do missing values differ by group (potential bias)?

```
ExpNumStat(ames,by="A",gp=NULL,round=2,Nlim=50) |>
  select(c("Vname","Group", "min", "max", "CV")) |>
  flextable() |>
  delete_part(part = "header") |>
  width(j = c("min","max","Vname"), width = 1) |>
  width(j = "Group", width = 1) |>
  width(j = "CV", width = 1.4) |>
#  set_table_properties(layout = "fixed")|>
```

```
add_header_row(
  values = c("Variable","Heating Group", "Minimum", "Maximum", "Coefficient of Variation")
bold(part = "header") |>
align(align = "center", part = "header")|>
theme_booktabs()
```

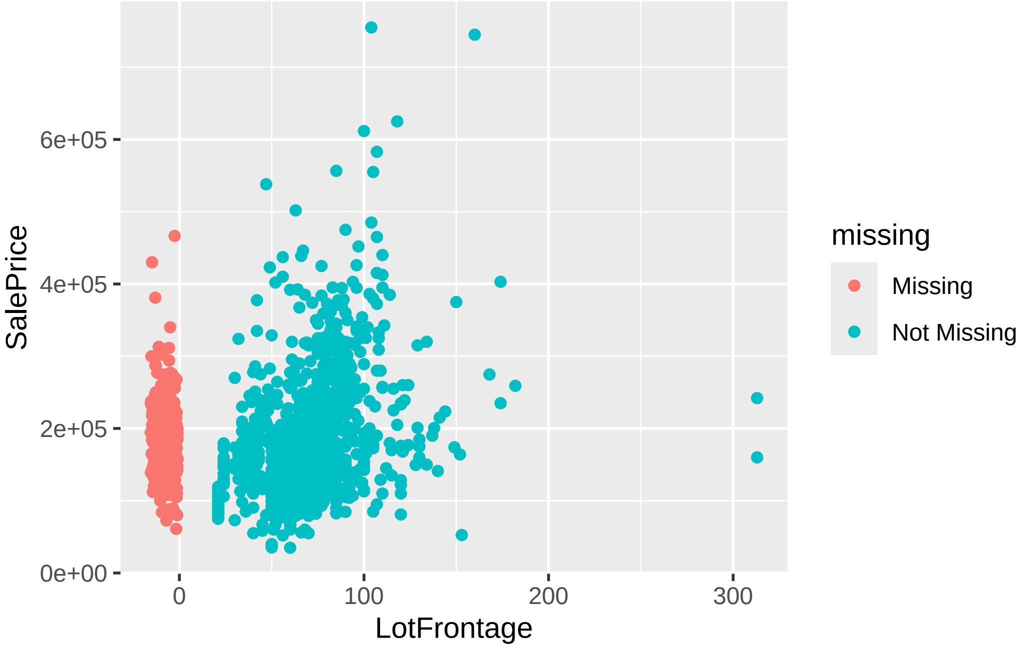
Variable	Heating Group	Minimum	Maximum	Coefficient of Variation
BsmtFinSF1	All	0	5,644	1.03
BsmtFinSF2	All	0	1,474	3.47
BsmtUnfSF	All	0	2,336	0.78
EnclosedPorch	All	0	552	2.78
GarageArea	All	0	1,418	0.45
GarageYrBlt	All	1,900	2,010	0.01
GrLivArea	All	334	5,642	0.35
Id	All	1	1,460	0.58
LotArea	All	1,300	215,245	0.95
LotFrontage	All	21	313	0.35
MasVnrArea	All	0	1,600	1.75
OpenPorchSF	All	0	547	1.42
SalePrice	All	34,900	755,000	0.44
ScreenPorch	All	0	480	3.70
TotalBsmtSF	All	0	6,110	0.41
WoodDeckSF	All	0	857	1.33
X1stFlrSF	All	334	4,692	0.33
X2ndFlrSF	All	0	2,065	1.26
YearBuilt	All	1,872	2,010	0.02
YearRemodAdd	All	1,950	2,010	0.01

```
#  autofit()
```

7) Missingness in scatterplots: is missingness related to outcome?

If LotFrontage is missing more often for low- or high-priced houses, the missingness may not be random (important for modelling decisions).

```
ames |>
  ggplot(aes(x=LotFrontage, y=SalePrice)) +
  geom_miss_point()
```



8) Example: zeros / rare values (PoolArea)

Understand the distribution of PoolArea. Often PoolArea is 0 for most houses (no pool) and positive for a few.

```
ames |>
  count(PoolArea)
```

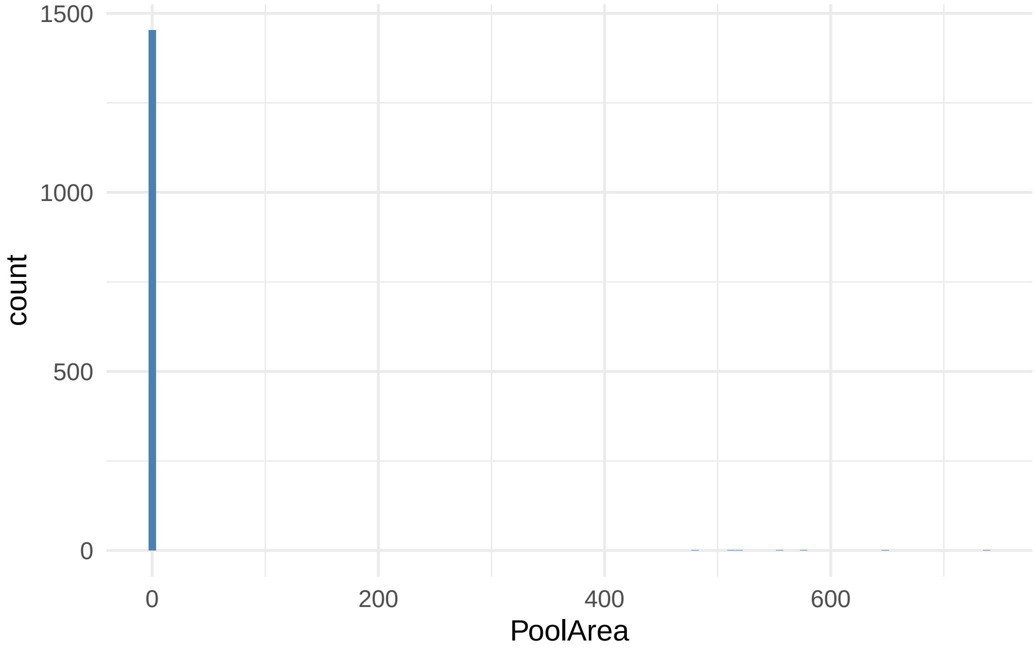
```
  PoolArea    n
1        0 1453
```

```
2       480    1
3       512    1
4       519    1
5       555    1
6       576    1
7       648    1
8       738    1
```

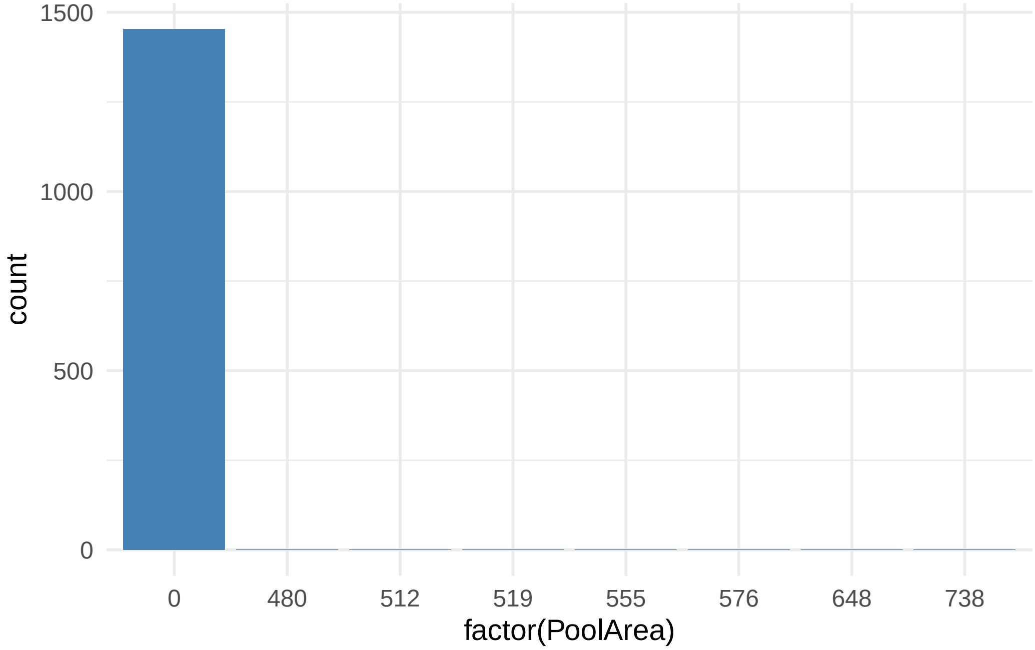
```
ames  |>
  summarise(meanpool = mean(PoolArea, na.rm = TRUE))
```

```
  meanpool
1 2.758904
```

```
ames  |>
ggplot(aes(x=PoolArea))+
  geom_bar(stat="count", fill="steelblue")+
  theme_minimal()
```



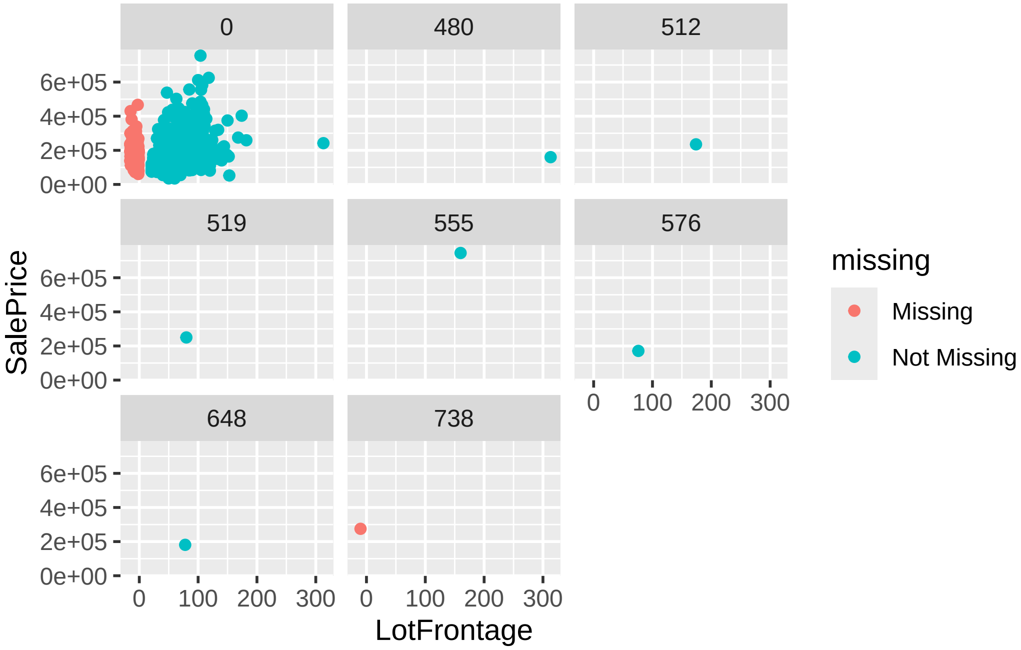
```
ames  |>
ggplot(aes(x=factor(PoolArea)))+
  geom_bar(stat="count", fill="steelblue")+
  theme_minimal()
```



9) Faceting to compare relationships across subgroups (PoolArea)

Does the LotFrontage–SalePrice relationship differ by PoolArea category? Faceting is a quick "small multiples" strategy to explore subgroup structure.

```
ames |>
  ggplot(aes(x=LotFrontage, y=SalePrice)) +
  geom_miss_point()+
  facet_wrap(~PoolArea)
```



10) Missingness by group + missingness by factor

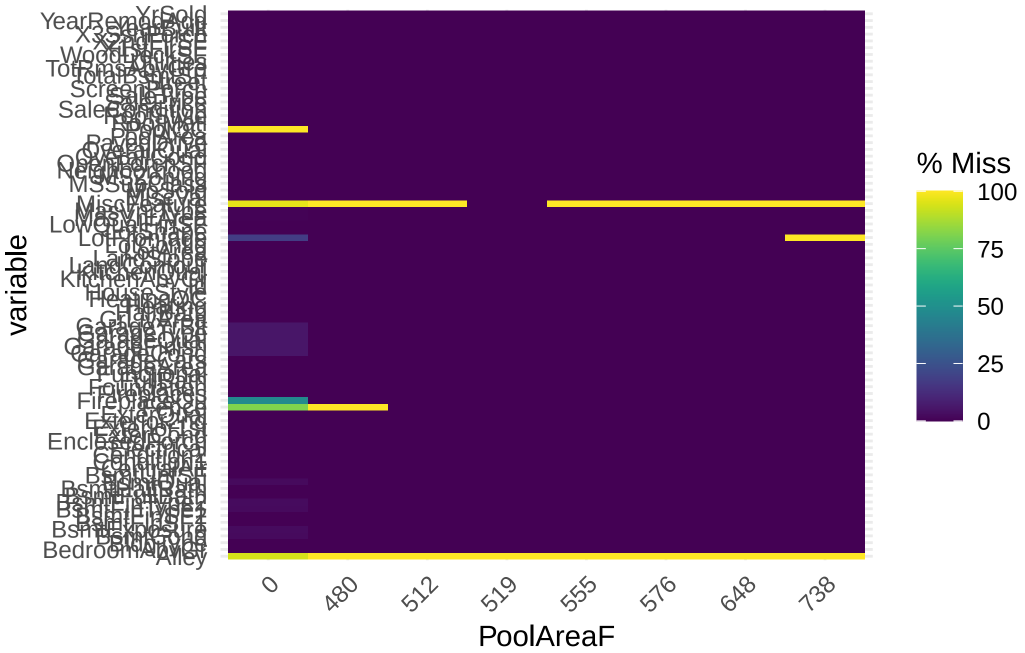
If missingness differs across groups, analyses can become biased.

```
ames |>
  group_by(Street) |>
  miss_var_summary()
```

```
# A tibble: 160 x 4
# Groups:   Street [2]
   Street variable     n_miss pct_miss
   <chr>  <chr>         <int>    <num>
 1 Pave   PoolQC         1447    99.5
 2 Pave   MiscFeature    1403    96.5
 3 Pave   Alley          1363    93.7
 4 Pave   Fence          1173    80.7
 5 Pave   FireplaceQu     686    47.2
 6 Pave   LotFrontage     258    17.7
 7 Pave   GarageType       80     5.50
 8 Pave   GarageYrBlt      80     5.50
 9 Pave   GarageFinish     80     5.50
10 Pave   GarageQual       80     5.50
# i 150 more rows
```

```r
ames <- ames |>
  mutate(PoolAreaF = as.factor(PoolArea))

gg_miss_fct(x=ames, fct = PoolAreaF)
```


variable
YrSold
Alley
PoolAreaF
% Miss