Lecture G2. Functional Approximation 2

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I. About

Diamonds dataset

```
help(diamonds)
```

Data Preparation

```
diamonds <- diamonds %>%
  filter(color == "G", carat < 1.75) %>%
  select(carat, cut, price)
str(diamonds)
```

```
## tibble [10,969 x 3] (S3: tbl_df/tbl/data.frame)
##  $ carat: num [1:10969] 0.23 0.23 0.28 0.31 0.31 0.24 0.7 0.78 0.74 0.75 ...
##  $ cut  : Ord.factor w/ 5 levels "Fair"<"Good"<..: 3 5 5 3 4 4 5 3 5 4 ...
##  $ price: int [1:10969] 354 404 553 553 553 554 2757 2759 2760 2760 ...
```

```
diamonds$cut %>% unique()
```

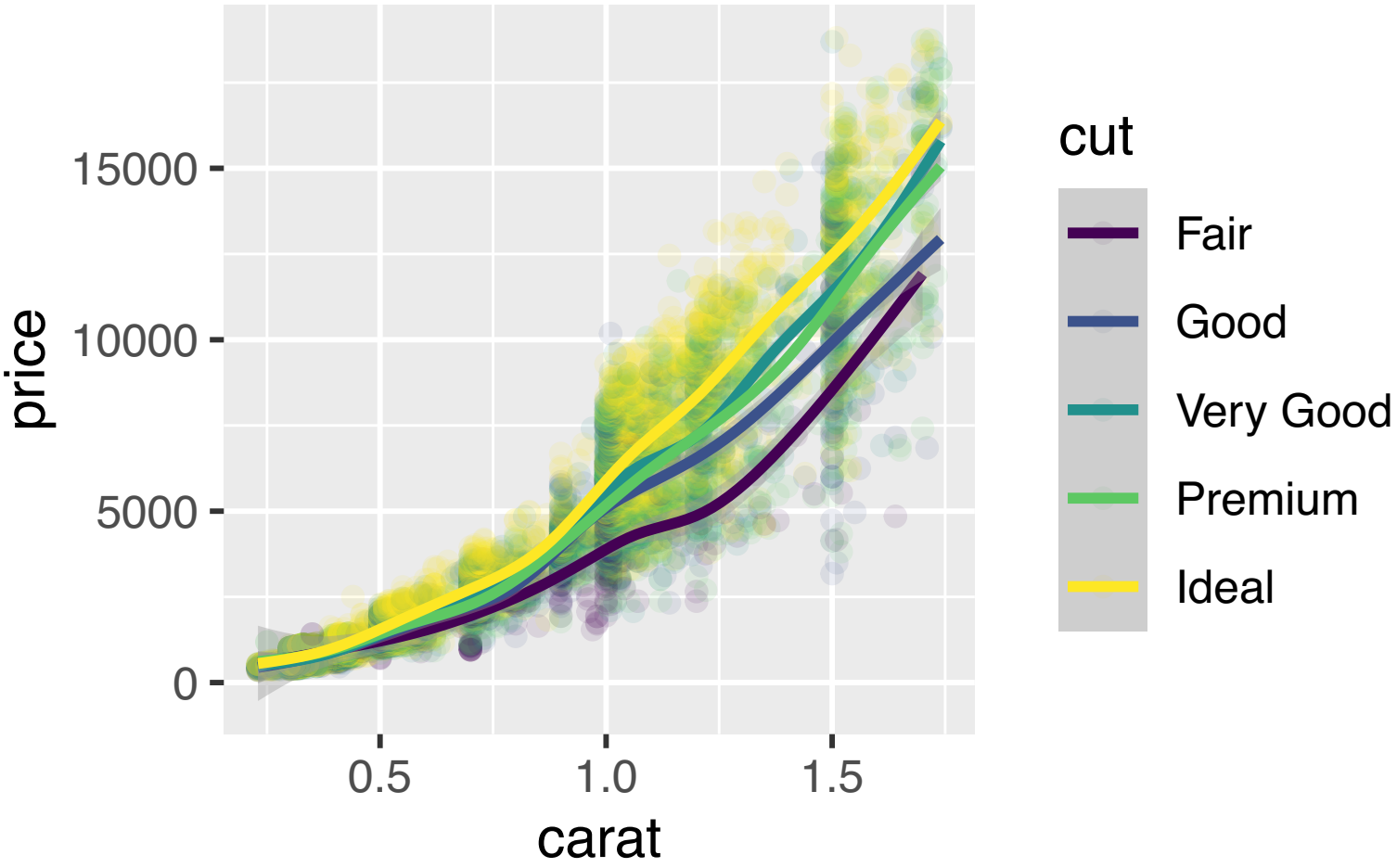
```
## [1] Very Good Ideal     Premium   Good      Fair
## Levels: Fair < Good < Very Good < Premium < Ideal
```

```
head(diamonds)
```

```
## # A tibble: 6 x 3
##   carat cut       price
##   <dbl> <ord>     <int>
## 1  0.23 Very Good   354
## 2  0.23 Ideal       404
## 3  0.28 Ideal       553
## 4  0.31 Very Good   553
## 5  0.31 Premium     553
```

Exploration

```
ggplot(diamonds, aes(x=carat, y=price, group=cut, color=cut)) +
  geom_point(alpha=0.1) + geom_smooth()
```



One-hot coding

```
library(mltools)
library(data.table)
diamonds$cut <- factor(diamonds$cut, ordered = FALSE)
diamonds <- diamonds %>% as.data.table() %>% one_hot()
head(diamonds)
```

```
##    carat cut_Fair cut_Good cut_Very Good cut_Premium cut_Ideal price
## 1:  0.23        0        0             1           0         0   354
## 2:  0.23        0        0             0           0         1   404
## 3:  0.28        0        0             0           0         1   553
## 4:  0.31        0        0             1           0         0   553
## 5:  0.31        0        0             0           1         0   553
## 6:  0.24        0        0             0           1         0   554
```

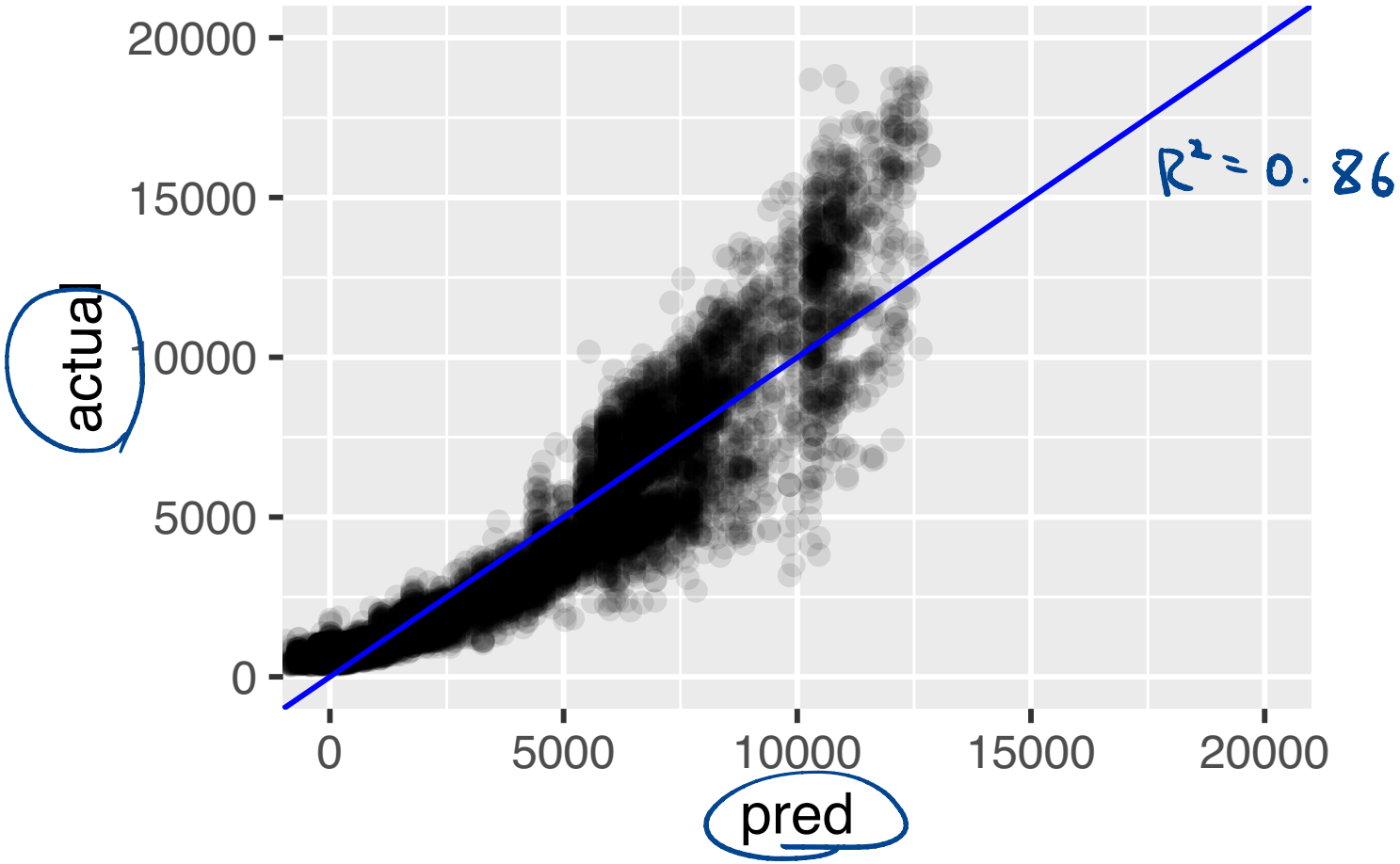
II. Linear regression

```r
lm_fit <- lm(price ~ carat + cut_Fair + cut_Good + `cut_Very Good` + cut_Premium, data=diamonds)
summary(lm_fit)
```

```
##
## Call:
## lm(formula = price ~ carat + cut_Fair + cut_Good + `cut_Very Good` +
##     cut_Premium, data = diamonds)
##
## Residuals:
##    Min     1Q Median     3Q    Max
##  -6654   -730     46    625   8409
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)      -2427.4       29.7   -81.8   <2e-16 ***
## carat             8761.3       33.3   263.2   <2e-16 ***
## cut_Fair         -1941.2       82.5   -23.5   <2e-16 ***
## cut_Good          -881.8       50.1   -17.6   <2e-16 ***
## `cut_Very Good`   -432.8       34.1   -12.7   <2e-16 ***
## cut_Premium       -430.7       31.9   -13.5   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1330 on 10963 degrees of freedom
## Multiple R-squared:  0.864,  Adjusted R-squared:  0.864
## F-statistic: 1.39e+04 on 5 and 10963 DF,  p-value: <2e-16
```

Fitted vs Actual

```
lm_fitted <- data.frame(pred=lm_fit$fitted.values, actual=diamonds$price)
ggplot(lm_fitted, aes(x=pred, y=actual)) +
  geom_point(alpha=0.1) + geom_abline(slope = 1, intercept = 0, color = "blue", size = 0.5) +
  coord_cartesian(xlim = c(0, 20000), ylim = c(0, 20000))
```

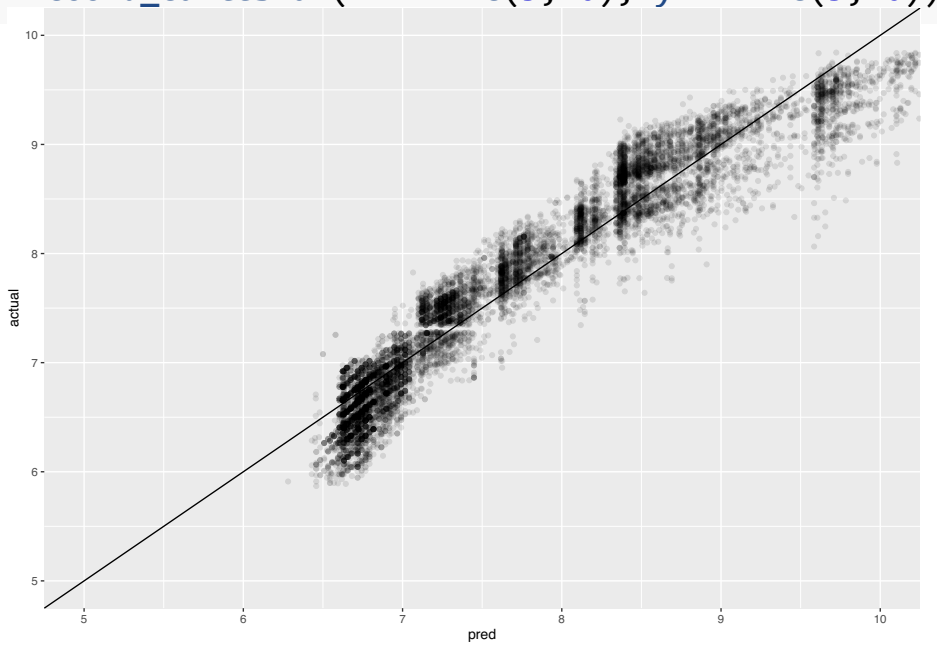


Side note

```
lm_fit_log <- lm(
  log(price) ~
  carat + cut_Fair + cut_Good + `cut_Very Good` +
  data=diamonds)
summary(lm_fit_log)$r.squared
```

```
## [1] 0.9184
```

```
lm_fitted_log <- data.frame(
  pred=lm_fit_log$fitted.values,
  actual=log(diamonds$price))
ggplot(lm_fitted_log, aes(x=pred, y=actual)) +
  geom_point(alpha=0.1) +
  geom_abline(slope = 1, intercept = 0) +
  coord_cartesian(xlim = c(5,10), ylim = c(5,10))
```



III. Deep Forward Network

Keras and Tensorflow

- Webpage https://tensorflow.rstudio.com/
- Installation https://tensorflow.rstudio.com/installation/

1. Anaconda installation
   - https://www.anaconda.com/products/individual

2. Install package `tensorflow` and `keras`

```
install.packages("tensorflow")
library(tensorflow)
install_tensorflow() # reticulate::py_install("tensorflow")
install.packages("keras")
```

3. Confirm installation

```
library(tensorflow)
tf$constant("Hello Tensorflow")
```

1. Construct a network

```
library(keras)
X <- diamonds %>% select(-cut_Ideal, -price) %>% as.matrix()
Y_actual <- diamonds %>% select(price) %>% as.matrix()
dim(X)
```

```
## [1] 10969     5
```

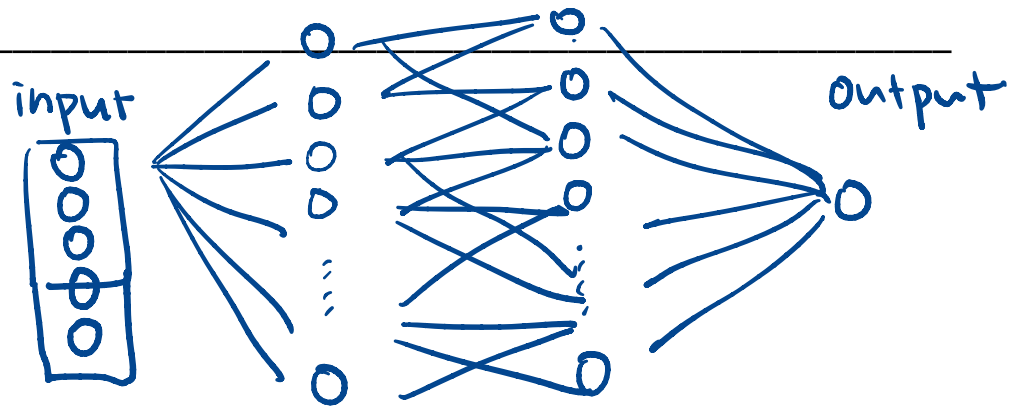
```
dim(Y_actual)
```

```
## [1] 10969     1
```

```
dense_fit <- keras_model_sequential() %>%
  layer_dense(units = 16, input_shape = c(5), activation = "relu") %>%
  layer_dense(units = 16, activation = "relu") %>%
  layer_dense(1, activation = "linear")
```

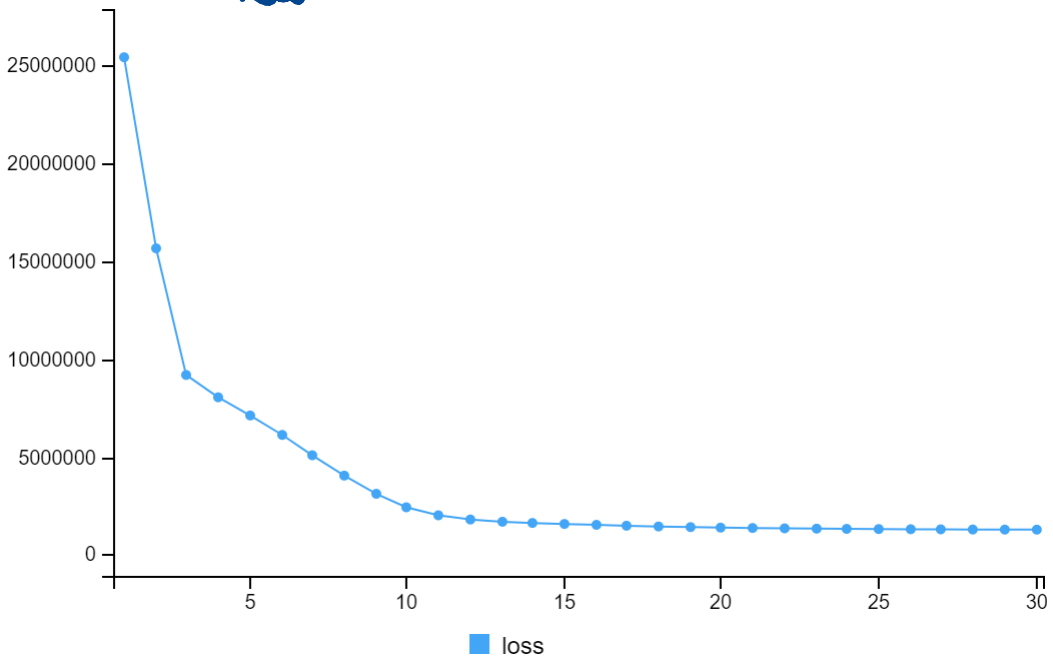
```
dense_fit %>% summary()
```

```
## Model: "sequential"
## _________________________________________________________________
## Layer (type)                 Output Shape              Param #
## =================================================================
## dense_2 (Dense)              (None, 16)                96
## _________________________________________________________________
## dense_1 (Dense)              (None, 16)                272
## _________________________________________________________________
## dense (Dense)                (None, 1)                 17
## =================================================================
## Total params: 385
## Trainable params: 385
## Non-trainable params: 0
## _________________________________________________________________
```



2. Compile and Fit

```
dense_fit %>% compile(loss = "mse", optimizer = "adam")
dense_fit %>% fit(X, Y_actual, epochs=30, batch_size=16)
```



3. Predict

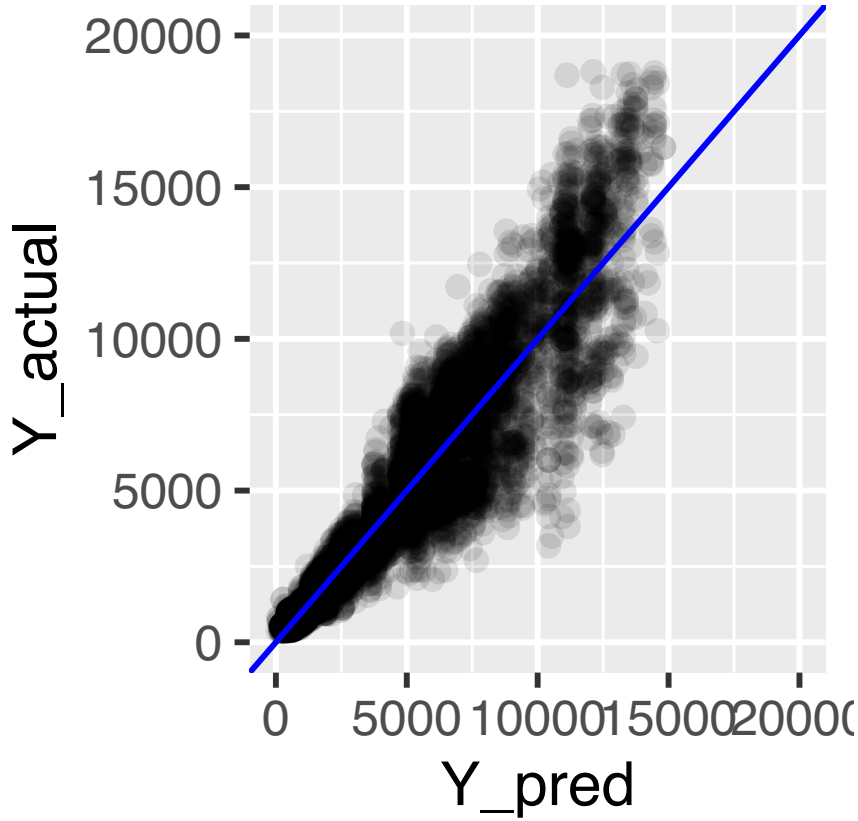
```
Y_pred <- dense_fit %>% predict(X)
results <- data.frame(Y_pred, Y_actual)
head(results)
```

```
##   Y_pred price
## 1  331.1   354
## 2  200.7   404
## 3  382.7   553
## 4  614.0   553
## 5  635.2   553
## 6  321.3   554
```

```
r_squared <- cor(Y_pred, Y_actual)^2
r_squared
```

```
##        price
## [1,] 0.9019
```

```
ggplot(results, aes(x=Y_pred, y=Y_actual)) +
  geom_point(alpha=0.1) +
  geom_abline(slope = 1, intercept = 0, color = "blue", size = 0.5) +
  coord_cartesian(xlim = c (0, 20000), ylim = c (0, 20000))
```



```
"It's not that I'm so smart, it's just that I stay with problems longer. - A. Einstein"
```