

Respiratory Rate Determination by Non-Invasive Means

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1 Introduction

1.1 Background

(Penzel et al., 2000).

1.2 The data

(Goldberger et al., 2000).

2 Methodologies and implementation

3 Appendix: workflow, code and output

3.1 Source code

The source codes for the functions used in the workflow are in the .R files at [/R](#).

3.2 Data wrangling and signal processing

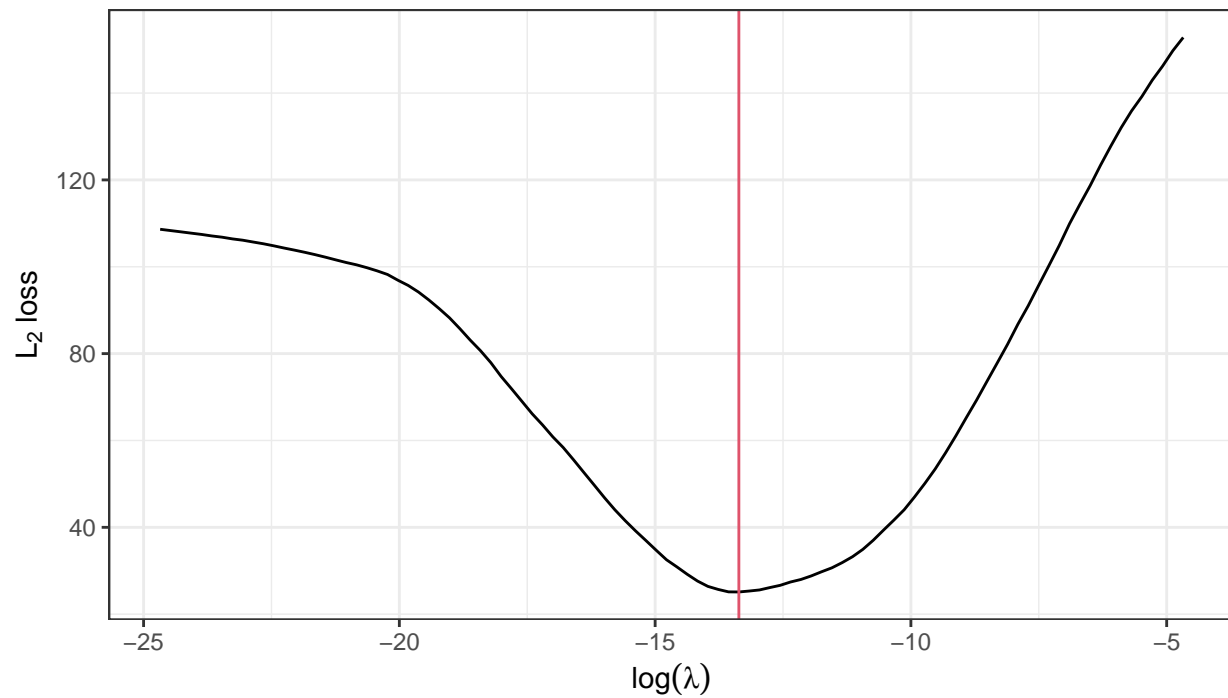
```
training_set <- c("a01", "a02", "a03", "a04", "b01")
test_set <- c("c01", "c02", "c03")
hr <- fuse_data(map(
  sprintf("../data-bin/%s.dat", training_set),
  function(ecg_file) {
    ecg_file |>
      read_ecg() |>
      find_r_peaks() |>
      frequency() |>
      down_sample()
  }
))
resp <- fuse_data(map(
  sprintf("../data-bin/%s.dat", training_set),
  function(ecg_file) {
    ecg_file |>
      read_ecg() |>
      find_r_peaks() |>
      frequency() |>
      down_sample()
  }
))
hr_test <- fuse_data(map(
  sprintf("../data-bin/%s.dat", test_set),
  function(ecg_file) {
    ecg_file |>
      read_ecg() |>
      find_r_peaks() |>
      frequency() |>
      down_sample()
  }
))
resp_test <- fuse_data(map(
  sprintf("../data-bin/%s.dat", test_set),
  function(ecg_file) {
    ecg_file |>
      read_ecg() |>
      find_r_peaks() |>
      frequency() |>
      down_sample()
  }
))
write_rds(hr, "../R/hr.rds")
write_rds(resp, "../R/resp.rds")
write_rds(hr_test, "../R/hr-test.rds")
write_rds(resp_test, "../R/resp-test.rds")
```

3.3 Model training

```
hr <- read_rds("../R/hr.rds")
resp <- read_rds("../R/resp.rds")
resp_df <- resp_dataset(hr, resp)
```

```
#> opt_lambda
#> 1.571851e-06
```

Regularisation result



```
resp_df
```

```
#> # A tibble: 2,526 x 2
#>   breath_chest breath_ecg
#>   <dbl>       <dbl>
#> 1      19.5        15
#> 2      22.5        16
#> 3      23.5       17.5
#> 4      20.5        18
#> 5      20.5        18
#> 6       23         15
#> 7       16         18
#> 8       20        21.5
#> 9       20        17.5
#> 10      18        16.5
#> # i 2,516 more rows
```

```
summary(resp_df)
```

```
#>   breath_chest   breath_ecg
#> Min.   : 5.50   Min.   :11.50
#> 1st Qu.:15.00   1st Qu.:17.50
#> Median :18.50   Median :19.00
#> Mean   :18.46   Mean   :18.96
#> 3rd Qu.:21.38   3rd Qu.:20.50
#> Max.   :29.00   Max.   :26.50
```

3.4 Model diagnostics

```
c("R-F cor" = with(resp_df, cor(breath_chest - breath_ecg, breath_ecg)))
```

```
#> R-F cor
```

```
#> -0.3976376
```

```
test <- lm(breath_chest ~ 0 + breath_ecg, resp_df)
c("p-value" = unname(pchisq(
  sum(resp_df$breath_ecg^2) * (coef(test) - 1)^2 *
    (nrow(resp_df) - 1) / sum(residuals(test)^2), 1,
  lower.tail = FALSE
)))
```

```
#> p-value
```

```
#> 2.983174e-13
```

```
confint(test)
```

```
#> 2.5 % 97.5 %
```

```
#> breath_ecg 0.9521173 0.9724053
```

3.5 Model evaluation

```
hr_test <- read_rds("../R/hr-test.rds")
resp_test <- read_rds("../R/resp-test.rds")
resp_dt <- resp_dataset(hr_test, resp_test, 1.571851e-06)
c("RMSEP" = with(resp_dt, sqrt(mean((breath_chest - breath_ecg)^2))))
```

```
#> RMSEP
```

```
#> 5.489861
```

References

- Goldberger, A. L., Amaral, L. A., Glass, L., Hausdorff, J. M., Ivanov, P. C., Mark, R. G., Mietus, J. E., Moody, G. B., Peng, C.-K., & Stanley, H. E. (2000). Physiobank, physiotoolkit, and physionet. *Circulation*, *101*(23), e215–e220.
- Penzel, T., Moody, G. B., Mark, R. G., Goldberger, A. L., & Peter, J. H. (2000). The apnea-ecg database. *Computers in Cardiology 2000*, 255–258.