

Time Series Analysis & Forecasting Using R

5. Time series features



Outline

- 1 STL Features
- 2 Lab Session 9
- 3 Dimension reduction for features
- 4 Lab Session 10

Outline

- 1 STL Features
- 2 Lab Session 9
- 3 Dimension reduction for features
- 4 Lab Session 10

Strength of seasonality and trend

STL decomposition

$$y_t = T_t + S_t + R_t$$

Seasonal strength

$$\max \left(0, 1 - \frac{\text{Var}(R_t)}{\text{Var}(S_t + R_t)} \right)$$

Trend strength

$$\max \left(0, 1 - \frac{\text{Var}(R_t)}{\text{Var}(T_t + R_t)} \right)$$

Feature extraction and statistics

```
tourism > features(Trips, feat_stl)
```

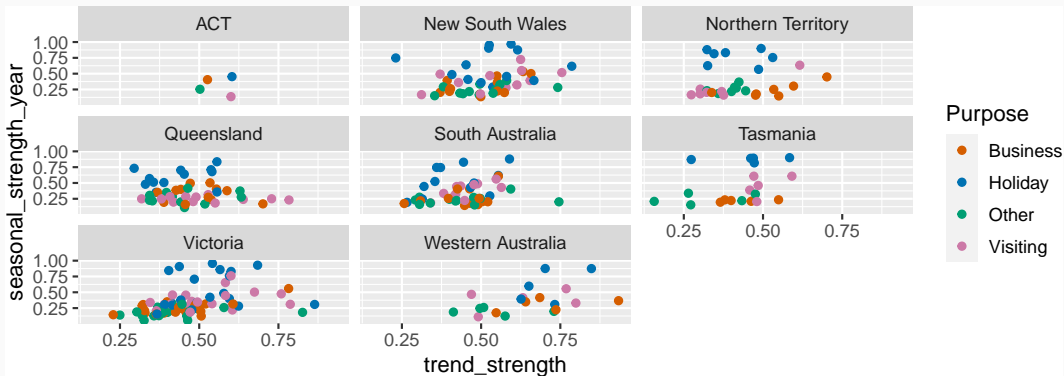
```
## # A tibble: 304 x 12
##   Region    State Purpose trend_strength seasonal_streng~ seasonal_peak_y~
##   <chr>    <chr> <chr>         <dbl>         <dbl>         <dbl>
## 1 Adelaide Sout~ Busine~      0.464         0.407           3
## 2 Adelaide Sout~ Holiday    0.554         0.619           1
## 3 Adelaide Sout~ Other      0.746         0.202           2
## 4 Adelaide Sout~ Visiti~    0.435         0.452           1
## 5 Adelaide~ Sout~ Busine~    0.464         0.179           3
## 6 Adelaide~ Sout~ Holiday    0.528         0.296           2
## 7 Adelaide~ Sout~ Other      0.593         0.404           2
## 8 Adelaide~ Sout~ Visiti~    0.488         0.254           0
## 9 Alice Sp~ Nort~ Busine~    0.534         0.251           0
## 10 Alice Sp~ Nort~ Holiday    0.381         0.832           3
## # ... with 294 more rows, and 6 more variables:
## #   seasonal_trough_year <dbl>, spikiness <dbl>, linearity <dbl>,
## #   curvature <dbl>, stl_e_acf1 <dbl>, stl_e_acf10 <dbl>
```

Feature extraction and statistics

tourism ▷

features(Trips, feat_stl) ▷

```
ggplot(aes(x = trend_strength, y = seasonal_strength_year, col = Purpose)) +  
geom_point() + facet_wrap(vars(State))
```

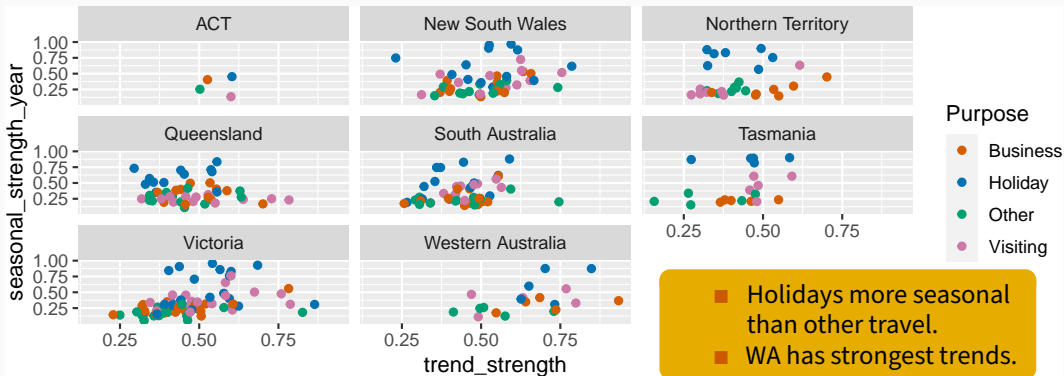


Feature extraction and statistics

tourism ▷

features(Trips, feat_stl) ▷

```
ggplot(aes(x = trend_strength, y = seasonal_strength_year, col = Purpose)) +  
geom_point() + facet_wrap(vars(State))
```



Feature extraction and statistics

Find the most seasonal time series:

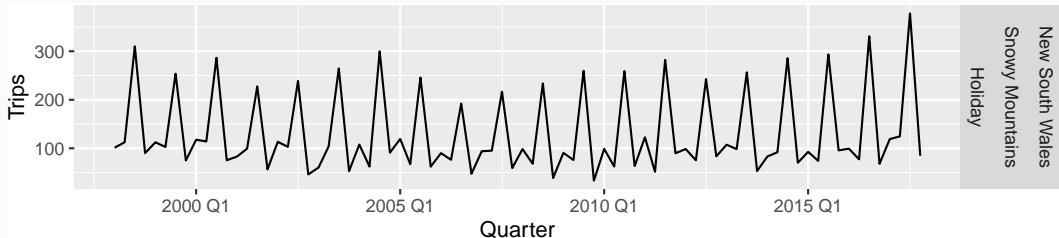
```
most_seasonal <- tourism ▷  
  features(Trips, feat_stl) ▷  
  filter(seasonal_strength_year == max(seasonal_strength_year))
```


Feature extraction and statistics

Find the most seasonal time series:

```
most_seasonal <- tourism ▷  
  features(Trips, feat_stl) ▷  
  filter(seasonal_strength_year == max(seasonal_strength_year))
```

```
tourism ▷  
  right_join(most_seasonal, by = c("State", "Region", "Purpose")) ▷  
  ggplot(aes(x = Quarter, y = Trips)) +  
  geom_line() + facet_grid(vars(State, Region, Purpose))
```



Feature extraction and statistics

Find the most trended time series:

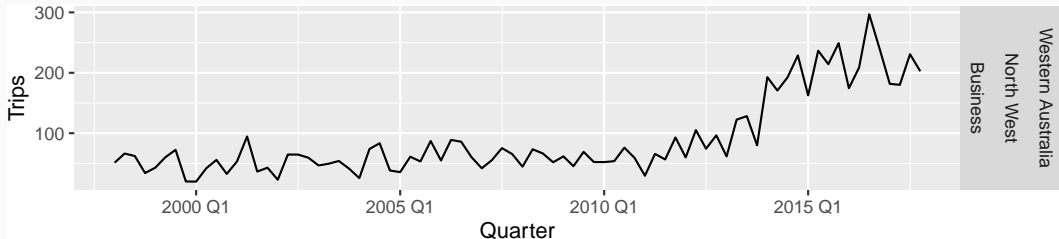
```
most_trended <- tourism ▷  
  features(Trips, feat_stl) ▷  
  filter(trend_strength == max(trend_strength))
```

Feature extraction and statistics

Find the most trended time series:

```
most_trended <- tourism ▷  
  features(Trips, feat_stl) ▷  
  filter(trend_strength == max(trend_strength))
```

```
tourism ▷  
  right_join(most_trended, by = c("State", "Region", "Purpose")) ▷  
  ggplot(aes(x = Quarter, y = Trips)) +  
  geom_line() + facet_grid(vars(State, Region, Purpose))
```



Outline

- 1 STL Features
- 2 Lab Session 9
- 3 Dimension reduction for features
- 4 Lab Session 10

Lab Session 9

- Use `GGally::ggpairs()` to look at the relationships between the STL-based features. You might wish to change `seasonal_peak_year` and `seasonal_trough_year` to factors.
- Which is the peak quarter for holidays in each state?

Feature extraction and statistics

```
tourism > features(Trips, feat_acf)
```

```
## # A tibble: 304 x 10
```

```
##   Region    State Purpose    acf1 acf10 diff1_acf1 diff1_acf10 diff2_acf1
##   <chr>    <chr> <chr>    <dbl> <dbl>    <dbl>    <dbl>    <dbl>
## 1 Adelaide Sout~ Busine~ 0.0333 0.131   -0.520    0.463   -0.676
## 2 Adelaide Sout~ Holiday 0.0456 0.372   -0.343    0.614   -0.487
## 3 Adelaide Sout~ Other    0.517 1.15    -0.409    0.383   -0.675
## 4 Adelaide Sout~ Visiti~ 0.0684 0.294   -0.394    0.452   -0.518
## 5 Adelaide~ Sout~ Busine~ 0.0709 0.134   -0.580    0.415   -0.750
## 6 Adelaide~ Sout~ Holiday 0.131 0.313   -0.536    0.500   -0.716
## 7 Adelaide~ Sout~ Other    0.261 0.330   -0.253    0.317   -0.457
## 8 Adelaide~ Sout~ Visiti~ 0.139 0.117   -0.472    0.239   -0.626
## 9 Alice Sp~ Nort~ Busine~ 0.217 0.367   -0.500    0.381   -0.658
## 10 Alice Sp~ Nort~ Holiday -0.00660 2.11   -0.153    2.11   -0.274
## # ... with 294 more rows, and 2 more variables: diff2_acf10 <dbl>,
## #   season_acf1 <dbl>
```

Outline

- 1 STL Features
- 2 Lab Session 9
- 3 Dimension reduction for features
- 4 Lab Session 10

Feature extraction and statistics

```
tourism_features <- tourism %>%  
  features(Trips, feature_set(pkgs = "feasts"))
```

All features from the feasts
package

```
## # A tibble: 304 x 51  
##   Region      State Purpose trend~1 season~2 season~3 season~4  
##   <chr>      <chr> <chr>    <dbl>    <dbl>    <dbl>    <dbl>  
## 1 Adelaide Sout~ Busine~ 0.464    0.407      3      1  
## 2 Adelaide Sout~ Holiday 0.554    0.619      1      2  
## 3 Adelaide Sout~ Other 0.746    0.202      2      1  
## 4 Adelaide Sout~ Visiti~ 0.435    0.452      1      3  
## 5 Adelaide H~ Sout~ Busine~ 0.464    0.179      3      0  
## 6 Adelaide H~ Sout~ Holiday 0.528    0.296      2      1  
## 7 Adelaide H~ Sout~ Other 0.593    0.404      2      2  
## 8 Adelaide H~ Sout~ Visiti~ 0.488    0.254      0      3  
## 9 Alice Spri~ Nort~ Busine~ 0.534    0.251      0      1  
## 10 Alice Spri~ Nort~ Holiday 0.381    0.832      3      1  
## # ... with 294 more rows, 44 more variables:  
## #   spikiness <dbl>, linearity <dbl>, curvature <dbl>,  
## #   stl_e_acf1 <dbl>, stl_e_acf10 <dbl>, acf1 <dbl>,  
## #   f10 <dbl>, f1 <dbl>, f5 <dbl>, f10 <dbl>
```


Feature extraction and statistics

```
pcs <- tourism_features %>%  
  select(-State, -Region, -Purpose) %>%  
  prcomp(scale = TRUE) %>%  
  broom::augment(tourism_features)
```

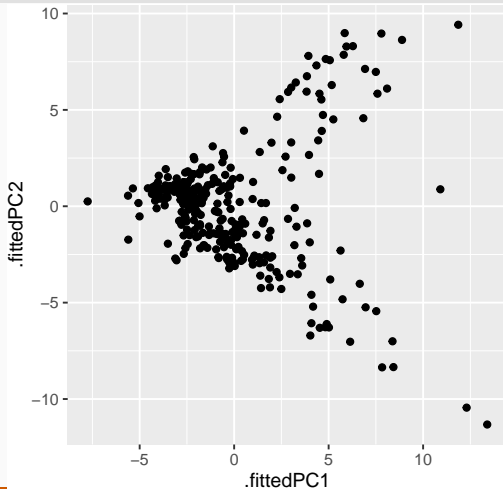
Principal components based
on all features from the feasts
package

```
## # A tibble: 304 x 100  
##   .rownames Region State Purpose trend~1 season~2 season~3  
##   <chr>      <chr>   <chr> <chr>    <dbl>    <dbl>    <dbl>  
## 1 1          Adelaide Sout~ Busine~ 0.464    0.407     3  
## 2 2          Adelaide Sout~ Holiday 0.554    0.619     1  
## 3 3          Adelaide Sout~ Other 0.746    0.202     2  
## 4 4          Adelaide Sout~ Visiti~ 0.435    0.452     1  
## 5 5          Adelaide~ Sout~ Busine~ 0.464    0.179     3  
## 6 6          Adelaide~ Sout~ Holiday 0.528    0.296     2  
## 7 7          Adelaide~ Sout~ Other 0.593    0.404     2  
## 8 8          Adelaide~ Sout~ Visiti~ 0.488    0.254     0  
## 9 9          Alice Sp~ Nort~ Busine~ 0.534    0.251     0  
## 10 10         Alice Sp~ Nort~ Holiday 0.381    0.832     3  
## # ... with 294 more rows, 93 more variables:
```

Feature extraction and statistics

```
pcs > ggplot(aes(x=.fittedPC1, y=.fittedPC2)) +  
  geom_point() + theme(aspect.ratio=1)
```

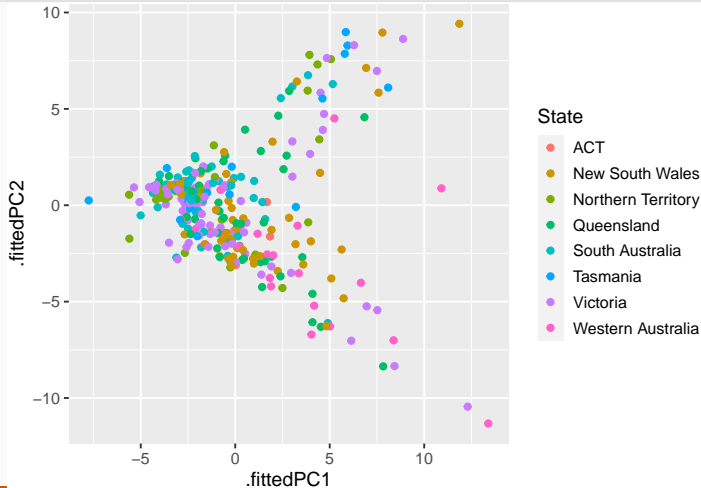
Principal components
based on all features
from the feasts
package



Feature extraction and statistics

```
pcs > ggplot(aes(x=.fittedPC1, y=.fittedPC2, col=State)) +  
  geom_point() + theme(aspect.ratio=1)
```

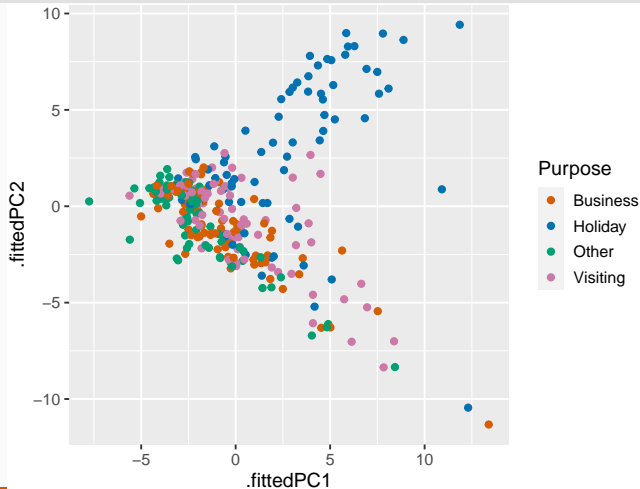
Principal components
based on all features
from the feasts
package



Feature extraction and statistics

```
pcs > ggplot(aes(x=.fittedPC1, y=.fittedPC2, col=Purpose)) +  
  geom_point() + theme(aspect.ratio=1)
```

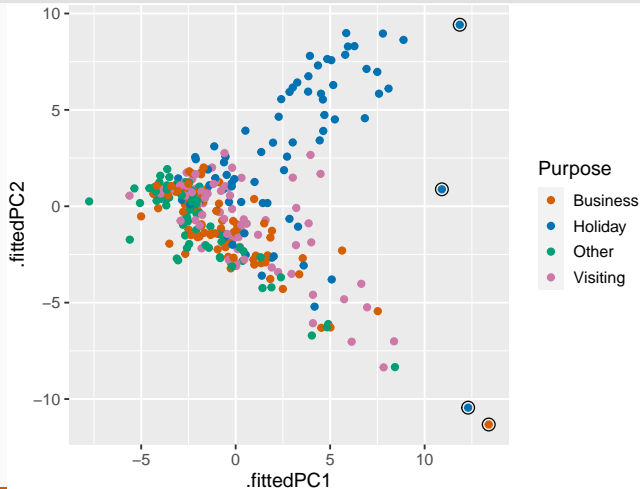
Principal components
based on all features
from the feasts
package



Feature extraction and statistics

```
pcs > ggplot(aes(x=.fittedPC1, y=.fittedPC2, col=Purpose)) +  
  geom_point() + theme(aspect.ratio=1)
```

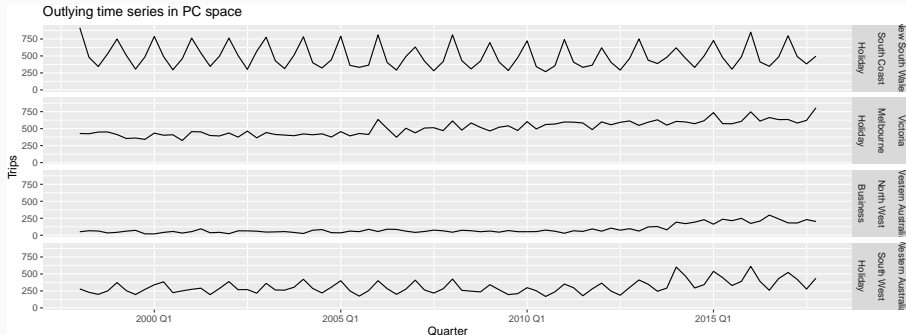
Principal components
based on all features
from the feasts
package



Feature extraction and statistics

outliers ▷

```
left_join(tourism, by = c("State", "Region", "Purpose")) ▷  
mutate(Series = glue("{State}", "{Region}", "{Purpose}", .sep = "\n\n")) ▷  
ggplot(aes(x = Quarter, y = Trips)) +  
geom_line() + facet_grid(Series ~ .) +  
labs(title = "Outlying time series in PC space")
```



Outline

- 1 STL Features
- 2 Lab Session 9
- 3 Dimension reduction for features
- 4 Lab Session 10

Lab Session 10

- Use a feature-based approach to look for outlying series in PBS.
- What is unusual about the series you identify as outliers?