

viewTRiAL Package - A technical guide

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2020-10-06

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1 About viewTRiAL

The viewTRiAL package is a R Shiny (package {shiny} version 1.5.0) web application prototype designed to build and deploy Centralized Monitoring R shiny web applications in clinical studies within the Department of Clinical Research at University of Basel.

2 Acknowledgements

- Concept development - Pascal Benkert, PhD, Senior Data Scientist (CTU Basel)
- App modularization and packaging inspiration from secuTrialRshiny package - Milica Markovic, PhD, Former Data Scientist (CTU Basel) & Patrick Wright, PhD, Senior Data Scientist (CTU Basel)
- Automation of secuTrial exports - Constantin Sluka, PhD, Service Head Data Science (CTU Basel)
- Secure logins to dashboard - Thomas Zumbunn, PhD, Head (CTU Basel) & Ramon Saccilotto, MD, Head (CTU Basel)

3 Install viewTRiAL

3.1 Installing from CTU's repository

```
setwd("~/repos/proj/piCentralizedMonitoring/R")
system("R CMD INSTALL viewTRiAL")
```

3.2 Installing from GitHub

```
library(devtools)
devtools::install_github("suvi-subra/viewTRiAL")
```

3.3 Running viewTRiAL

```
library(viewTRiAL)
run_app()
```

4 Let's get started!

The prototype has been developed as Shiny modules to address namespacing problems in Shiny User interface (UI) and server logic and to facilitate working through huge amount of code. In order to develop a production-grade Shiny App, the framework from the {golem} package version 0.2.1 was used. The structure of a golem framework is the same as that of a typical R package except that it allows for simplified development and deployment of packaged R Shiny applications.

4.1 Load, prepare and save your data (data-row/)

For maximum efficiency in running your app, each time you launch it, you do not want it to be loaded more than once. Since we are packaging our R Shiny app, we can take advantage of storing data as internal data, making it unavailable to users. A script that loads, prepares and saves the data as internal data is stored under the data-row/ folder. This script does not run automatically when the app is launched. Therefore, a line to run the script can be incorporated in the app_server.R file.

We use dummy datasets in this prototype app. The structure of each dataset is displayed.

4.1.1 Baseline data

This is baseline data containing one row for each patient. The pat_id, centre, withdrawal status, randomization date and informed consent dates are included.

```
str(dummy_baseline)
#> 'data.frame': 100 obs. of 5 variables:
#> $ pat_id : int 100 51 13 40 90 50 31 79 7 61 ...
#> $ centre : Factor w/ 5 levels "A","B","C","D",...: 4 3 5 3 2 5 2 2 3 1 ...
#> $ withdrawn : logi FALSE FALSE FALSE FALSE FALSE FALSE ...
#> $ date_random.date : Date, format: "2019-08-15" "2019-08-23" "2020-04-28" "2020-06-04" ...
#> $ date_consent.date: Date, format: "2019-08-15" "2019-08-23" "2020-04-28" "2020-06-04" ...
```

4.2 Track your development (dev/)

The dev/ folder is used as a notebook to track steps of the development process. There are 3 files:

4.2.1 01_start.R

This file should be filled at the start. It contains functions to fill the DESCRIPTION file, set options and list dependencies.

4.2.2 02_dev.R

This file should be filled to set the structure of core functionalities such as creating modules and other R functions. One is able to create a new module (eg.mod_overview.R) by calling `golem::add_module(name = "overview")` and a R file (eg.filename.R) by calling `usethis::use_r("filename")`.

4.2.3 03_deploy.R

Finally, this file contains functions that aid in deploying the app via Rstudio or Docker. This file contains functions to create either an app.R file or Docker file to deploy the app depending on the portal you choose. This is a necessary step as the R Shiny web application is packaged and does not conform to the standard structure of app deployment. We will return to this file again in a later section dedicated to deployment.

4.3 Start developing (R/)

Core functions of the app are stored under the R/ folder.

4.3.1 app_ui.R

This function displays the input from its counterpart `app_server()`. Below is an example of how a menu item in the sidebar of a dashboard is created and its corresponding module called to display the content on the dashboard body.

```
app_ui <- function(request) {  
  
  fluidPage(  
    dashboardPage(skin = "purple",  
  
    dashboardHeader(title = "Study name", titleWidth = 300),  
    dashboardSidebar(  
      sidebarMenu(  
        ## 1. Create a new menu item here. List tabName in get_modules.R.  
        menuItem("Overview", tabName = mod$overview, icon = icon("chart-pie"))  
      )  
    ),  
    dashboardBody(  
      tabItems(  
        ## 2. Call the module corresponding to the menu item here  
        mod_overview_ui(id = mod$overview, label = mod$overview)  
      )  
    )  
  )  
}
```

There are 4 items to adapt in this file:

1. `dashboardHeader(title)`: Change the study name
2. `dateRangeInput(inputId)`: Replace the name of the date filter depending on the date used to filter the data. (eg. Enrolment date). This filter may be commented if not needed.
3. `dateRangeInput(label)`: Replace the date ranges for filtering.
4. `selectInput(choices, selected)`: Replace the vector of centers and default center to be selected. This filter may be commented if not needed.

```
app_ui <- function(request) {  
  
  ## Get module label names  
  mod <- get_modules()  
  
  ## Leave this function for adding external resources  
  golem_add_external_resources()  
  ## List the first level UI elements here  
  fluidPage(  
    dashboardPage(skin = "purple",  
    ## Header  
    ## TODO (1): Change study name  
    dashboardHeader(title = "Study name", titleWidth = 300),  
    ## Sidebar  
    dashboardSidebar(width = 300,  
      sidebarMenu(  
        ## TAB 1: Overview
```

```

menuItem("Overview", tabName = mod$overview, icon = icon("chart-pie")),
## TAB 2: Performance measures
menuItem("Performance measures", icon = icon("chart-pie"),
  ## TAB 2.1: Recruitment and retention
  menuSubItem("Recruitment and Retention", tabName = mod$recruitment),
  ## TAB 2.2: Informed consent and eligibility
  menuSubItem("Informed consent and Eligibility", tabName = mod$consent),
  ## TAB 2.3: Data quality
  menuSubItem("Data Quality", tabName = mod$quality)),
## TAB 3: Study management
menuItem("Study Management", icon = icon("chart-pie"),
  ## TAB 3.1: Visits
  menuSubItem("Visits", tabName = mod$visits),
  ## TAB 3.2: Biosampling
  menuSubItem("Biosampling/Imaging data", tabName = mod$lab),
  ## TAB 3.3: Safety
  menuSubItem("Safety management", tabName = mod$safety),
  ## TAB 3.4: Staff management
  menuSubItem("Staff management", tabName = mod$staff)),
## FILTER: Date range
## TODO (2): Replace 2nd argument "Randomization date:"
dateRangeInput(inputId = "period", label = "Randomization date:",
  ## TODO (3): Replace date ranges
  start = as.POSIXct("2019-06-01"),
  end = as.POSIXct(today())),
## FILTER: Center
## TODO (4): Replace 3rd argument "choices" with a vector of centers
selectInput("center", "Center",
  choices = c("All", sort(levels(dummy_baseline$centre))),
  selected = "All"),
width = "350")),
## Body
dashboardBody(
  tabItems(
    ## TAB 1: Overview
    mod_overview_ui(mod$overview, label = mod$overview),
    ## TAB 2.1: Recruitment and retention
    mod_recruit_ui(mod$recruitment, label = mod$recruitment),
    ## TAB 2.2: Informed consent and eligibility
    mod_consent_ui(mod$consent, label = mod$consent)
  )
) ## dashboardBody
) ## dashboardPage
) ## fluidPage
}

```

4.3.2 app_server.R

This file contains the server logic. In this file, reactive dataframes are created and a `callModule()` corresponding to the module UI created in `app_ui.R` is called. Starting in Shiny 1.5.0, it is recommended to use `moduleServer()` instead of `callModule()` as it can be tested with `testServer()`. However, in our prototype since we have additional parameters to pass to each module function, we will stick to using `callModule()` as `moduleServer()`.

will not be able to handle that.

There are 4 items to adapt in this file:

1. The input dataframes in both filter functions and callModule(data1)
2. The variable names of centre and filter date

```
#' The application server-side
#
#' @param input,output,session Internal parameters for {shiny}.
#' DO NOT REMOVE.
#' @import shiny
#' @noRd
app_server <- function(input, output, session) {

  ## Get module label names
  mod <- get_modules()

  ## Create reactive dataframes
  bl_period <- reactive(

    if(input$center != "All"){
      ## TODO (1): Replace input dataframe
      ## TODO (2): Change variable names "centre" and "date.random.date"
      filter(df = dummy_baseline,
             centre == input$center &
             date_random.date >= input$period[1] &
             date_random.date <= input$period[2])

    } else{
      ## TODO (3): Replace input dataframe
      ## TODO (4): Change variable names "centre" and "date.random.date"
      filter(df = dummy_baseline,
             date_random.date >= input$period[1] &
             date_random.date <= input$period[2])
    })

  # List the first level callModules here
  ## Overview tab
  ## TODO (5): Replace input dataframe in argument data1
  callModule(mod_overview_server, mod$overview, data1 = bl_period)
  callModule(mod_recruit_server, mod$recruitment, data1 = bl_period)
  callModule(mod_consent_server, mod$consent, data1 = bl_period)

}
```

4.3.3 app_config.R

This file contains a get_golem_config() that retrieves app config. No changes to make here.

4.3.4 get_modules.R

This file contains a list of module label names. No changes to make here unless you add a new module.

4.3.5 mod_overview.R

This file contains the ui and server functions for the “Overview” tab. The “Overview” tab contains the following:

- value boxes displaying the number of patients, randomized, currently active and withdrawn
- line plot displaying recruitment over time by centers

Here there are no changes required unless one wants to add value boxes for additional figures or plots.

```
## overview UI Function
##
## @description A shiny Module.
##
## @param id,input,output,session Internal parameters for {shiny}.
##
## @noRd
##
## @importFrom shiny NS tagList
mod_overview_ui <- function(id, label){
  ns <- NS(id)

  tabItem(tabName = label,
    fluidRow(
      ## No.of participants randomized
      valueBoxOutput(ns("randomized"), width = 12)
    ),

    fluidRow(
      valueBoxOutput(ns("active"), width = 6),
      valueBoxOutput(ns("withdrew"), width = 6)
    ),

    fluidRow(
      ## Plot displaying no.of participants randomized across acute centers
      box(
        width = 6,
        height = "600",
        title = "Recruitment by centers",
        status = "primary",
        plotlyOutput(ns('recruitplot'), height = "500"),
        solidHeader = TRUE,
        collapsible = FALSE),
      )
  )
}

## overview Server Function
##
## @noRd
mod_overview_server <- function(input, output, session, baseline.data){
  ns <- session$ns
```

```

output$randomized <- renderValueBox({
  valueBox(value = nrow(baseline.data()), subtitle = "Randomized", color = "green")
})

output$withdrew <- renderValueBox({
  ## Fill in the value of withdrawn
  no <- baseline.data() %>% filter(withdrawn == TRUE) %>% nrow()
  valueBox(value = no, subtitle = "Withdrawn", color = "red")
})

output$active <- renderValueBox({
  no <- baseline.data() %>% filter(withdrawn == FALSE) %>% nrow()
  valueBox(value = no, subtitle = "Currently active", color = "blue")
})

output$recruitplot <- renderPlotly({
  ## Enrolment plot data
  plot_recruitment(baseline.data(), "date_random.date", "centre")

})
}

```

4.3.6 mod_recruit.R

```

#' recruit UI Function
#'
#' @description A shiny Module.
#'
#' @param id,input,output,session Internal parameters for {shiny}.
#'
#' @noRd
#'
#' @importFrom shiny NS tagList
mod_recruit_ui <- function(id, label){
  ns <- NS(id)
  tabItem(tabName = label,
    fluidRow(
      ## Expected sample size
      valueBoxOutput(ns("expected"), width = 6),
      valueBoxOutput(ns("actual"), width = 6)
    )
  )
}

#' recruit Server Function
#'
#' @noRd
mod_recruit_server <- function(input, output, session, baseline.data){

```



```

ns <- session$ns

output$expected <- renderValueBox({
  ## TODO: Enter expected sample size
  valueBox(value = 250, subtitle = "Expected sample size", color = "blue")
})

output$actual <- renderValueBox({
  ## TODO: Enter expected sample size
  no <- baseline.data() %>% nrow()
  ## TODO: Determine percentage
  percent <- round(no/250*100, digits = 1)
  valueBox(value = paste0(no, " (", percent, "%)", subtitle = "Recruited", color = "green")
})
}

```

4.3.7 mod_consent.R

4.3.8 plot_recruitment.R

4.3.9 run_app.R

4.4 Deploy the app

We will now return to have a look at the dev/03_deploy.R file. Here we have several ways to deploy the app. For example, if you would like to deploy your app on shinyapps.io, you will have to run the following function to create an app.R file at the root of the package. This file calls the `pkgload::load_all()` function then in return calls the `run_app()` function which launches the package.

```
golem::add_shinyappsio_file()
```

5 References

1. Fay, C., Rochette, S., Guyader, V. and Girard, C. (2020) Engineering Production-Grade Shiny Apps, Available at: <https://engineering-shiny.org/index.html> (Accessed: 28th September 2020).
2. Wickham, H. and Bryan, J. (2020) R Packages, Available at: <https://r-pkgs.org/index.html> (Accessed: 28th September 2020).