

The traitr package

John Verzani

verzani at math dot csi dot cuny dot edu

July 14, 2010

Abstract

This vignette describes the **traitr** package. This package provides an interface to GUI design within R in the spirit of the **Traits UI** python module. The basic idea is that the user specifies the type of data that is desired, and the package gives a reasonable GUI to edit that data.

1 Five-minute, or so, introduction

The **traitr** package is intended to provide a natural, relatively easy means to produce GUIs for underlying functions. The design was inspired by the **Traits UI** python module (<http://code.enthought.com/projects/traits>), although the implementation is not nearly as feature rich as that.

The **Traits UI** interface uses the model-view-controller design pattern. The main idea is that a user specifies a model consisting of possibly many properties, each holding data of a certain type. Each property we call an item. A view of the model is specified by indicating which items are to be shown along with a layout. The items themselves know how to present themselves graphically so that the user can interact, or edit, the values. One then ties the model and view together by specifying some common methods (a controller).

This provides a simple map between a function with arguments (whose values are of a certain type) and a GUI to edit these values, which makes the writing of basic GUI dialogs for R functions very straightforward – no GUI programming is needed.¹

The **traitr** package uses **gWidgets** to provide a link to a graphical toolkit. At this point it works with **gWidgetsRGtk2** and **gWidgetsQt**, but there are issues with **gWidgetstcltk**.

There are a few means available now within R to have GUIs automatically written for you such as **fgui** and the **ggenericwidget** function in **gwidgets**. The basic idea employed is an inspection of a function's arguments to determine the type of data expected and the a determination of the appropriate widget for editing that type. This package provides **dialogMaker** to do so, but also make it easy for the user to just specify the data type for the arguments to make a GUI.

The basic unit in **traitr** is an item, which is an object that knows what type of value it should hold and how to represent that value in a GUI. Since the programmer knows the type of value they

¹This vignette documents version 0.9 of the package.

want, this isn't difficult to provide, yet the GUI creation aspect is mostly hidden from sight – unless the programmer wishes to change the defaults. The GUI for an item is referred to as an editor, as in most cases, the primary usage is to display the underlying value for editing.

At this point, there are a few basic type of items listed in Table 2. Adding more is on the TODO list.

1.1 A first example

To begin with `traitr`, we load the package and specify a `gWidgets` implementation.

```
require(traitr)
require(gWidgets)
options(guiToolkit="RGtk2")
```

An item constructor is called with a default value and possibly many other values. Items may be combined into “item groups” or “dialogs,” the latter being an item group with a window and a set of buttons.

To see how a simple GUI can be made, here we construct a GUI to collect a number and string:

```
dlg <- aDialog(items=list(
  number=numericItem(0),
  string=stringItem("")
)
)
dlg$make_gui() # method call using $ notation.
```

The `aDialog` constructor returns a `proto` object for which there are many methods defined, but just a few that are necessary to know. In this instance, we use the dialog's `make_gui` method to create the GUI. To see other documented methods and properties of the `proto` objects produced, call their `show_help` method.² That is, this command will produce a web page with the information for the `dlg` instance: `dlg$show_help()`.

The default dialog GUI has three buttons, an OK button (which when clicked prints out the values in the GUI), a Cancel button to dismiss the dialog and a Help button to call up a simple help string, which in this example is not implemented. To change the buttons, one assigns the names to the `buttons` property of the dialog. The values “Undo” and “Redo” will implement the undo/redo pattern for the underlying model.

To override the default behaviours or to assign actions to other buttons, one defines methods for the dialog object using a certain naming convention. For the dialog buttons, if one defines a function (`buttonname_handler`), then this will be called when the button “buttonname” is clicked. For example, to make the dialog do something else, we have:

²The `proto` package extends R's environments to implement a prototype programming style. To call a function, we use the `$` notation to reference the function. Unlike storing a function in a regular environment, this function call passes back into the function, as the first argument, a reference to the `proto` object. As such, the function signature would be something like (`self`, `arg1`, `arg2`), where `self` is used here for familiarity with javascript (another prototype language). However, it is traditional to use `.` as this variable instead of `self`, so we use this in the code, as needed.

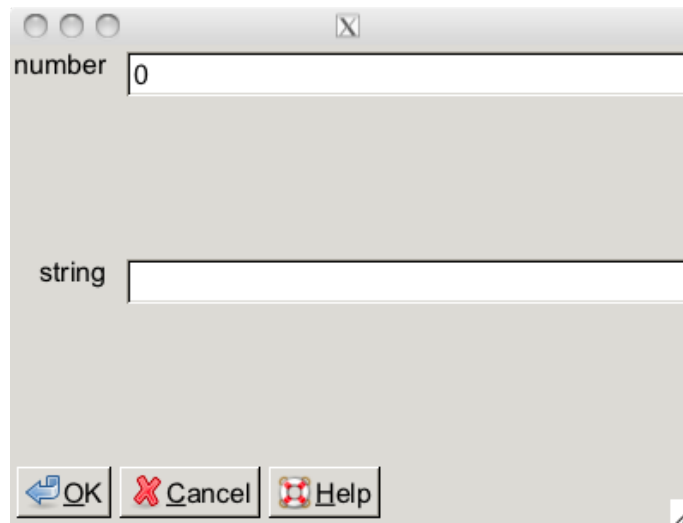


Figure 1: Basic interface with two items, a number and string.

```
dlg <- aDialog(items=list(
  number=numericItem(0),
  string=stringItem("")
),
  OK_handler=function(.) { # . is reference to dlg object
    values <- .$to_R()
    f <- function(number,string)
      cat("number is", number, "string is", string, "\n")
    do.call(f, values)
  }
)
dlg$make_gui()
```

The function `OK_handler` becomes a method of the `proto` object, so its lone argument `.` passes into the function body the `proto` object. (These objects are environments, so the usual pass by copy is not used, rather this is the same object.) Its method `to_R` returns a named list of the values stored for each item in the dialog – which is convenient for `do.call` – and this handler simply echoes them back in a friendly manner. Individual properties in the dialog can be accessed through “getters.” These follow the naming convention `get_PROPERTYNAME`, as in

```
dlg$get_number()
```

```
[1] 0
```

(The `number` is the name assigned to the item. In this case – since it is not specified in an argument – it gets it from the named component of the list where the item is defined.)

To make a less trivial dialog we just need to have more complicated functions. What follows is a dialog (Figure 2) for computing a t -test when the values are summarized. First a function to compute the p -value.

```
basic.t.test <- function(mean, mu, sd, alternative=c("two.sided", "less", "greater"),
                          n, ...) {
  alternative <- match.arg(alternative)
  obs <- (mean - mu)/(sd/sqrt(n))
  switch(alternative,
    "greater" = 1 - pt(obs, df=n-1),
    "less" = pt(obs, df=n-1),
    2*(1 - pt(abs(obs), df=n-1))
  )
}
```

Our dialog setup is similar, but we have more variables that need their type specified:

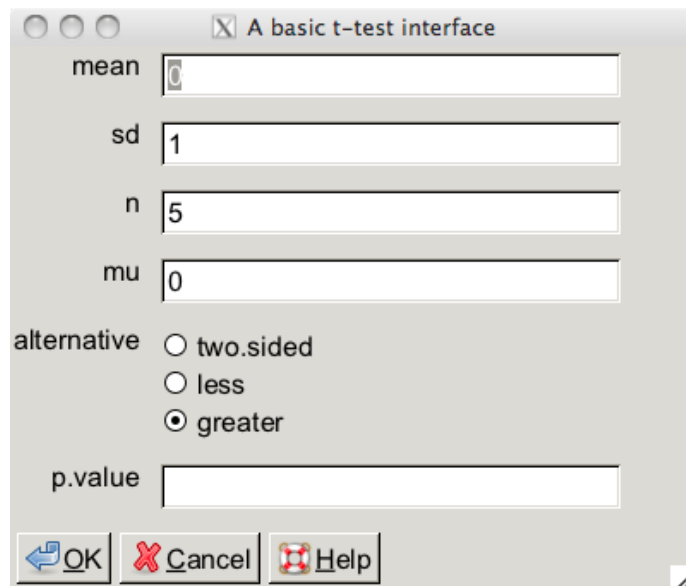
```
dlg <- aDialog(items=list(
  mean=numericItem(0),
  sd=numericItem(1),
  n=numericItem(5),
  mu=numericItem(0),
  alternative=choiceItem("two.sided", values=c("two.sided", "less", "greater")),
  output=stringItem("", label="p.value")
),
title="A basic t-test interface",
help_string="Enter in summarized values then click OK to get the p-value",
OK_handler=function(.) {
  lst <- .$to_R()
  lst$output <- NULL      # not really needed, ignored by function
  out <- do.call("basic.t.test", lst)
  .$set_output(out)
}
)

dlg$make_gui()
```

Here we used the `choiceItem` to provide a choice to the user. As well, we added values for the title and help string. The handler has the method call `set_output` to set the value to show in the output widget. When a dialog is created, both “`get`” and “`set`” methods are created for each item specified, where `output` matches the `name` property of the item (which is specified through the named list passed to `items`).

1.2 Views

The default GUI layout uses a 2-column table to organize the items. To modify this, one creates an alternate view or layout for the items. There are a few view constructors, similar to the containers in `gWidgets`. Table 5.1 lists them.



A basic t-test interface

mean

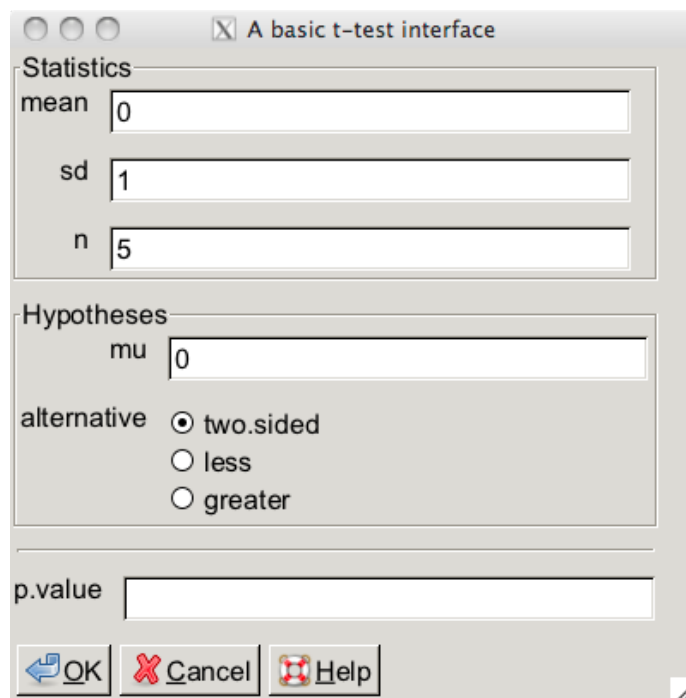
sd

n

mu

alternative ☐ two.sided
☐ less
☒ greater

p.value

Figure 2: Basic t -test interface

A basic t-test interface

Statistics

mean

sd

n

Hypotheses

mu

alternative ☒ two.sided
☐ less
☐ greater

p.value

Figure 3: The t -test interface using an alternate view that separates off the statistics from the hypotheses.

The basic layout is equivalent to:

```
view <- aContainer("mean", "sd", "n", "mu", "alternative", "output")
```

The `aContainer` constructor simply lays out its child components using a two-column table, one for the label and one for the widget representing the item. The items are specified by name. (The name can be explicitly set when the item is constructed, e.g. `numericItem(1, name="x")` or, as in the example, found from using a named list to define the items.)

To make a more complicated layout, we nest the containers. Here is how one can separate out the computed values from the hypotheses using frames:

```
view <- aContainer(aFrame("mean", "sd", "n", label="Statistics"),
                  aFrame("mu", "alternative", label="Hypotheses"),
                  "output")
```

However, this view will not align values, as the `aFrame` container is just a box container. Instead we add in another level with `aContainer` (Figure 3):

```
view <- aContainer(aFrame(aContainer("mean", "sd", "n"), label="Statistics"),
                  aFrame(aContainer("mu", "alternative"), label="Hypotheses"),
                  separatorItem(),
                  "output")
```

To see this in action, to save typing, we use the `instance` method, which for this purpose simply copies the dialog object. Then to specify a view different than the default, we use the `gui_layout` argument of the `make_gui` method:

```
dlg1 <- dlg$instance() ## instead of copying the definition above.
dlg1$make_gui(gui_layout=view)
```

1.3 Validation

Items use the model-view-controller design pattern, with a transport phase from view to model that allows for inspection of values. As such, we can check for valid input when assigning from the view to the model.³ When an item has invalid input, some signal is specified. To see it, try typing in a non-numeric value in where a number is expected.

To see how to specify our own validation function,⁴ we first write the function, then add it to the item. For the standard deviation, we shouldn't be able to specify non-positive standard deviations. A function to check this would be:

```
positive_value <- function(., rawvalue) {
  value <- as.numeric(rawvalue)
  if(!value > 0)
    stop("value is not positive")
  value
}
```

³Although we allow invalid input for technical reasons. It isn't until the call to `to_R` that an issue will arise.

⁴Validation is done for the main value stored in an item. For more complicated items using more than one main property, one can define `validate_PROPERTYNAME` methods.

The `.` argument is the item instance (not the dialog, say) and the argument `rawvalue` comes from the widget. (In this case a string, so we coerce the value before testing.) The validation functions should throw an error with a message if not valid. (The item itself has a `coerce_with` method to carry out the proper coercion.)

To add to a numeric item, we assign to its `validate` method: ⁵

```
sd <- numericItem(1, name="sd")
sd$validate <- positive_value
```

To do this for our dialog object, we can grab the item from the dialog, then specify its validation method:

```
sd <- dlg$get_item_by_name("sd")          # lookup and return item by name
sd$validate <- positive_value             # assigns method to item
dlg1 <- dlg$instance()
dlg1$make_gui(gui_layout=view)
```

1.4 Conditional layout

Parts of a view can be enabled conditioned on other parts of the GUI. In this example we make a GUI (Figure 4) for a one or two-sample *t*-test. As some options (such as `paired`) only make sense when two samples are specified, we enable those only when a possible value for `y` is specified. In the `x` and `y` items, the argument `eval=TRUE` is specified, which causes the specified value to be parsed and evaluated in the global environment. This allows the user to specify a variable name or R expression for the variable, and not just a number.

```
dlg <- aDialog(items=list(
  x = numericItem(NA, eval=TRUE),
  y = numericItem(NA, eval=TRUE),
  alternative=choiceItem("two.sided",
    values=c("two.sided", "less", "greater")),
  mu = numericItem(0),
  paired=trueFalseItem(FALSE),
  var.equal=trueFalseItem(FALSE)
),
title="GUI with some parts disabled"
)
view <- aContainer("x",
  aContext("y", context=dlg,
    enabled_when=function(.) { # y depends on x
      ## . here is the context value, not the container object
      val <- .$to_R()$x
      !is.null(val) && !is.na(val) && (nchar(val) > 0)
    }
  ),
```

⁵Here we see the ease of using the `proto` package, but it is also a burden. It is quite possible to assign to a “private” method, thereby having very unintended side effects that can be hard to debug.

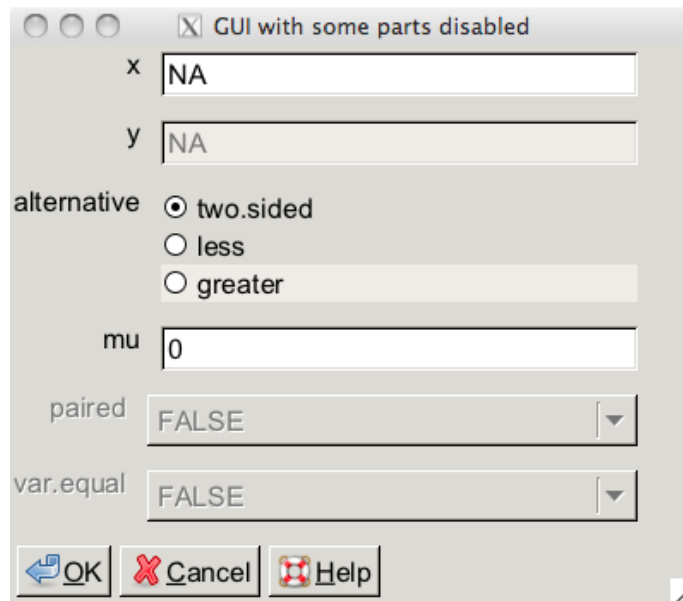


Figure 4: A t -test interface with some items having sensitivity depending on values of other items.

```

    "alternative",
    "mu",
    aContainer("paired", "var.equal", context=dlg,
               enabled_when=function(.) {
                 val <- .$to_R()$y
                 !is.null(val) && !is.na(val) && (nchar(.$get_y()) > 0)
               })
  )
  dlg$make_gui(gui_layout=view)

```

The `aContext` container is used to specify optional arguments to the view, but does not do any layout. In this case, the `y` value is conditioned on the value specified for `x`. The `context` argument specifies a dialog (or item group) where the variable is to be looked up.

1.5 Why wait?

The basic dialog calls a function when the OK button is clicked. Making a more interactive GUI, say to update when a value is changed, can be done by creating a method `model_value_changed`. For example, here is a GUI (Figure 5) to draw a graph for a random sample of size n .

```

drawGraph <- function(n,...) hist(rnorm(n))
dlg <- aDialog(items=list(
  n=rangeItem(10, from=1, to=100, by=1),
  graph=graphicDeviceItem()

```

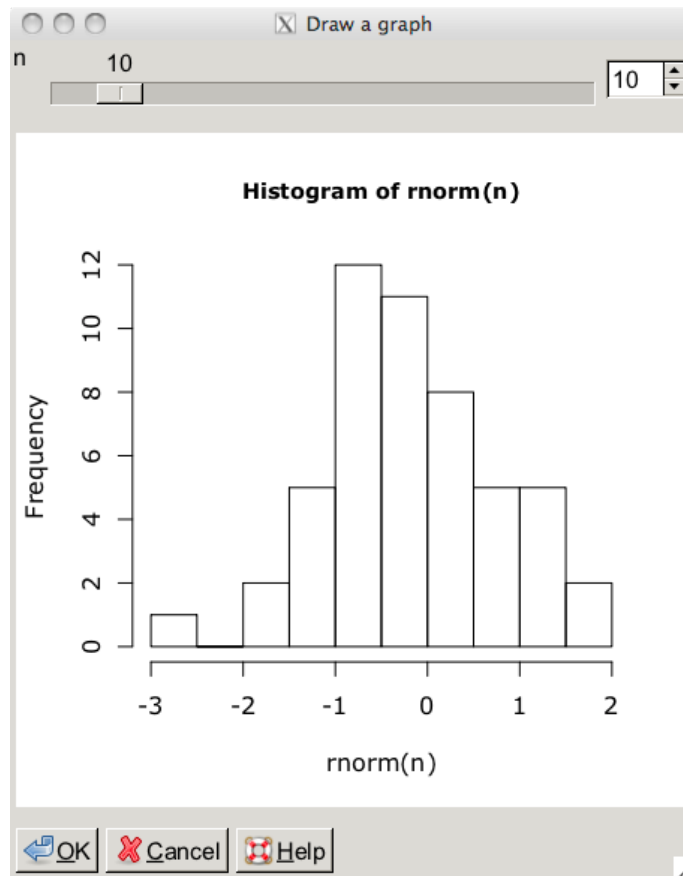



Figure 5: GUI where slider movement updates the graphic.

```

    ),
    title="Draw a graph",
    help_string="Adjust slider or click OK to produce a new graph",
    model_value_changed=function(.) {
      l <- .$to_R()
      l$graph <- NULL      # not really necessary
      do.call("drawGraph", l)
    },
    OK_handler=function(.) do.call("drawGraph", .$to_R())
  )
  dlg$make_gui()

```

The dialog is a model that observes itself for changes. When such a change occurs, methods matching a certain naming convention are called. The `model_value_changed` method, if present, is always called when any property is changed.

Table 1: Table of item constructors.

Constructor	Description
<code>stringItem</code>	For holding strings
<code>numericItem</code>	For numbers
<code>integerItem</code>	For integers
<code>expressionItem</code>	For R expressions
<code>trueFalseItem</code>	For Boolean values
<code>choiceItem</code>	For choosing one or more values from a list of possible values
<code>rangeItem</code>	To select a value from a range of values
<code>buttonItem</code>	For adding a button
<code>labelItem</code>	For adding a label
<code>dateItem</code>	For editing a calendar date.
<code>separatorItem</code>	To add a visual separator
<code>dataframeItem</code>	To select a data frame
<code>variableSelectorItem</code>	To select a variable from a data frame
<code>graphicDeviceItem</code>	(RGtk2 only) To embed a graphic device
<code>formulaItem</code>	For formula specification (to be written)
<code>dfeditItem</code>	To edit a data set (to be written)
<code>itemList</code>	An item that stores a list of other items (or itemgroups)

2 Items

The basic object in **traitr** is an item. An item includes a model to keep track of its value(s), an editor (the view) to create a GUI to edit the value(s) and a controller to link the two. In addition, items may include methods for validation of its values. Following the design of **Traits UI**, items allow the programmer to focus on the type of value, not the GUI presentation of the value.

Items are constructed through one of the item constructors. Table 2 lists the currently available ones. The constructors have some common arguments: **value** to specify the initial value of the item; **name** to specify the unique name for the item within a dialog (this can also be specified through a named list); **label** for a text label to identify the argument (defaults to **name**); **tooltip** to specify a tooltip for the widget, should it provide one; **attr** to pass arguments to the **gWidgets** constructor underlying the editor; **model** to specify a model for the item (models can be shared, or a new one will be created); and **editor** to specify a different editor.

In addition to these, each item has some item-specific arguments. For example, **numericItem** and **integerItem** have an argument **eval_first** which if set to **TRUE** will force the value from the editor to be evaluated within the global environment as a string.

The **choiceItem** provides a means to choose a value for a specified list of values. The editor may use a radio button group, a checkbox group, a combobox or a table widget to present the choice depending on the size of the list of values and whether multiple selection is possible. The constructor has two arguments, **value** to specify the initially chosen value and **values** to specify the list to choose from. The former can be specified by value (the default) or by index (if **by_index=FALSE** is give). The latter may be a vector or data frame.

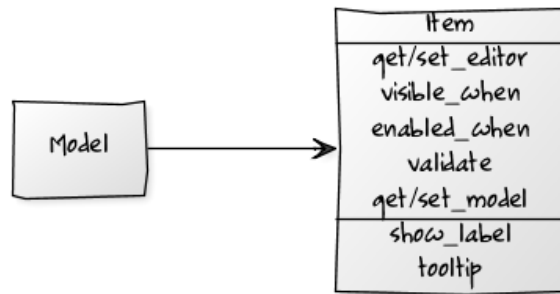


Figure 6: Standard methods and properties for an Item. (All UML diagrams come from <http://yuml.me/>)

The `dataframeItem` constructor provides a means to select a data frame. The `variableSelectorItem` constructor requires such an object to be passed to it, in order for it to have a context to find names in. For example

```

dfi <- dataframeItem(value=".GlobalEnv", name="dfi",
                     editor_style="compact") # alternative editor style
dlg <- aDialog(items=list(
  dfi,
  vsi=variableSelectorItem("", multiple=FALSE, dataframeItem=dfi,
    attr=list(size=c(200,200)))
))
dlg$make_gui()

```

The `itemList` constructor is used to create a list of items or item groups. See 6.3 for examples.

2.1 Item groups

An `ItemGroup` is used by `aDialog` to combine more than one item into a unit which acts as the model for the GUI. The `anItemGroup` constructor is similar to that for a dialog, but is used if one wants to embed the resulting GUI into some `gWidgets` container without the buttons, menubar, and toolbar options.

Item groups implement the model interface, described in the next section.

Item groups can allow for reuse of parts of a GUI. In this example, we see how we can separate some pieces out that are common to both a *t*-test and a Wilcox test call:

```

hyps <- anItemGroup(items=list(
  mu=numericItem(0),
  alternative=choiceItem("two.sided", c("two.sided", "less", "greater"))
),
gui_layout=aFrame("mu", "alternative", label="Hypotheses")
)
ttestDialog <- aDialog(items=list(

```

```

        x=numericItem(NA, eval=TRUE),
        y=numericItem(NA, eval=TRUE),
        hyps$instance()
      ),
      OK_handler=function(.) {
        do.call("t.test", .$to_R())
      }
    )
  wilcoxDialog <- aDialog(items=list(
    x=numericItem(NA, eval=TRUE),
    y=numericItem(NA, eval=TRUE),
    hyps$instance()
  ),
  OK_handler=function(.) {
    do.call("wilcox.test", .$to_R())
  }
  )
  ttestDialog$make_gui()
  wilcoxDialog$make_gui()          # shares alt info!

```

The use of `instance` ties the models together, but allows for multiple views. This may not be desirable. If two independent realizations are desired, then creating a factory (a function) to produce new instances of `hyps` would be suggested.

3 Models

Each item (and item group) implements a model interface. The underlying items uses the model-view-controller design pattern. A model is a object with a means to store and access properties and a mechanism to notify observers when these properties have changed.

3.1 Getters/Setters

Each model property has `get` and `set` methods to interact with the value stored in the model. For an item with a given name, say `x`, there are always methods `get_x` to get the value and `set_x` to set the value. The `get` method returns a raw value, unlike the method `to_R` which returns a value after coercion to the appropriate type. For example:

```

i <- numericItem(0, name="item1")
i$get_item1()

[1] 0

i$set_item1(3)
i$get_item1()

[1] 3

```

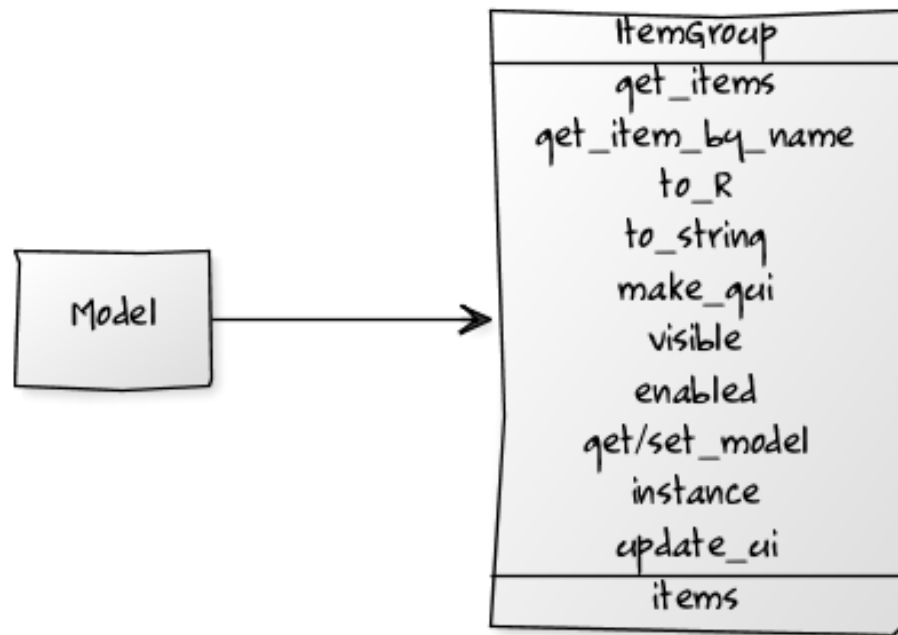


Figure 7: Standard methods and properties for an item group.

```

try(i$set_item1("c(1,2,3)"))          # fails validation, still stored in model

Not a valid value: Error in function (., value) :
  (converted from warning) NAs introduced by coercion

i$get_item1()

[1] NA

Where as, we can have the value run through eval to have:

i <- numericItem(0, name="item2", eval=TRUE)
i$set_item2("c(1,2,3)")                # now okay
i$get_item2()

[1] 1 2 3

i$to_R()                              # coerced

$item2
[1] 3
  
```

Item groups and dialogs also implement these methods, as they act as models with several properties:

```

dlg <- aDialog(items=list(
  x=numericItem(0),
  y=stringItem("a")
))

dlg$get_x()

[1] 0

dlg$set_y("some string")
dlg$get_y()

[1] "some string"

```

3.1.1 Getting/Setting other values in an item

If an item in an item group has more than one main property, the main getter/setter pairs created from each item name do not suffice. For example, the choice item has a main property for setting the value, but another property to store the values to choose from. To access a secondary property, we first extract the item by name with the `get_item_by_name` method of item groups, and then use the item's getter/setter values. For example:

```

ig <- anItemGroup(items=list(
  x=numericItem(1),
  y=choiceItem("a", values=letters[1:5])
))

ig$get_y()

[1] "a"

i <- ig$get_item_by_name("y")
i$get_y()                                # same as above

[1] "a"

i$get_values()                           # get values

[1] "a" "b" "c" "d" "e"

i$set_values(letters)                    # to set values

```

3.2 Observers

Models implement the observer pattern. An observer is notified whenever a specific model property changes or if any of the model's properties changes. To do so, the observer (which is a model instance like an item, item group, or dialog; or a controller) would have methods `model_value_changed` which is called whenever any property is changed or `property_NAME_value_changed` which is called when a given property is changed.

To add an observer to a model, the **add_observer** method is used, whereas **remove_observer** is provided to remove the observer. This example defines two dialogs, the second with a suitably named method and then has the second observer change in the first.

```
dlg <- aDialog(items=list(
  x=numericItem(0),
  y=numericItem(0)
)
)
dlg1 <- aDialog(items=list(
  a=numericItem(0)
),
property_x_value_changed=function(., value, old_value) {
  .set_a(.get_a() + value) # add value to a (assumes numeric)
}
)
dlg$add_observer(dlg1)
dlg1$get_a()

[1] 0

dlg$set_x(10)
dlg1$get_a()                                # updated by x

[1] 10
```

A dialog listens to itself, which allows the change of one property to update another. This example shows how the image is updated whenever the file is changed.

```
dlg <- aDialog(items=list(
  f=fileItem(""),
  i=imageItem("",attr=list(size=c(480,480)))
),
property_f_value_changed=function(., value, old_value) {
  .set_i(value)
},
buttons="Cancel")
dlg$make_gui()
```

The **model_value_changed** method has previously been illustrated. This method is called whenever any value is changed in the model.

3.3 Sharing a model

An item can share a model with another item. This allows for synchronization of values in a GUI. There are several means to do this: specifying the model at construction, calling the **set_model** method, or calling the **instance** method. For example,

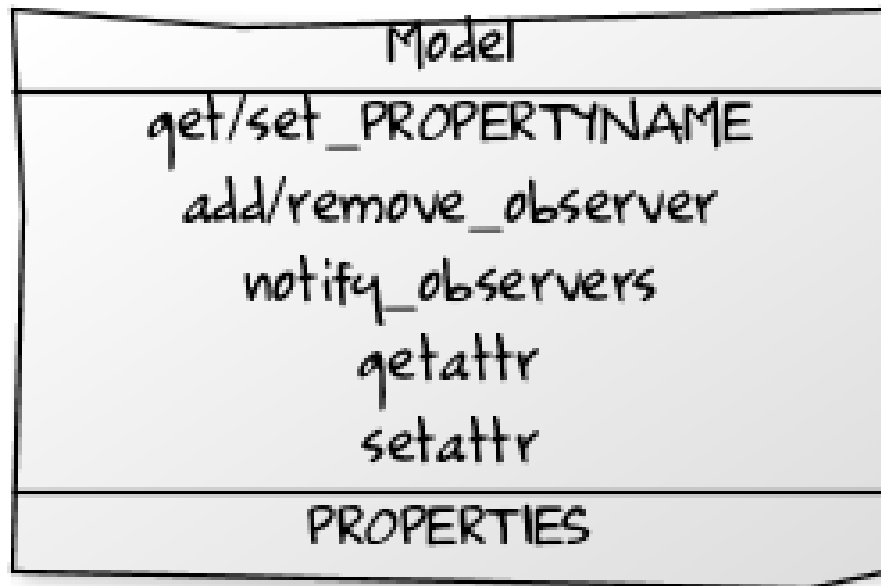


Figure 8: Standard methods and properties for a model.

```

i <- numericItem(0, name="x")
j <- numericItem(1, name="x")
j$get_x()

[1] 1

j$set_model(i)
j$get_x()

[1] 0

i$set_x(10)
j$get_x()

[1] 10

```

The `instance` method also creates a new item with a shared model, or as seen, a new dialog with shared models. There can only be one GUI for an instance of an item, but different instances can have GUIs, allowing multiple views for the same model.

4 Dialogs

Dialogs and item groups combine several items into a model, with different properties. In addition to the getter/setter methods, there is the useful `get_item_by_name` to retrieve a given item, and `to_R` method to get the values as a named list.

A dialog is an item group which creates its own top-level window. As such, dialogs have options for decorating the window: e.g., to add menubars, toolbars, and statusbars etc. We've seen how specifying the title and help string at construction is done through the argument `title` and `help_string`.

The top-level container is constructed by a call to the `make_gui` method. To close the GUI programmatically, the `close_gui` method is available.

4.1 Menubars, toolbars, statusbars

Menu bars and toolbars are specified using `gWidgets` objects. Basically, a list of `gaction` objects (of `gWidgets`) are specified to the dialog properties `menu_list` and `toolbar_list`.

```
mb_l <- list(File=list(
  New=gaction("new", icon="new", handler=function(h,...) print("New")),
  Quit=gaction("quit", icon="quit", handler=function(h,...) dlg$close_gui())
))
tb_l <- list(Quit=gaction("quit", icon="quit", handler=function(h,...) dlg$close_gui()))
dlg <- aDialog(items=list(x=stringItem("some value")),
  menu_list=mb_l,
  toolbar_list=tb_l,
  title="Dialog with menu and toolbar")
dlg$make_gui()
```

A status bar is created if the value of the `status_text` property is non `NULL`, say `""`, when `make_gui` is called. If there is a status bar, the method `update_status_text` is provided.

4.2 Buttons

Dialogs have a default set of buttons: `OK`, `Cancel` and `Help`. When clicked these call the methods `OK_handler`, `Cancel_handler` and `Help_handler`. As well, buttons named `Undo` and `Redo` have default handlers if specified. Likely, only `OK_handler` will need to be overridden. An example was previously given.

To specify other buttons, simply provide the names to the `buttons` property prior to construction of the GUI. For example, to have a GUI whose closure depends on the value of `x` being changed, we might have:

```
dlg <- aDialog(items=list(
  x=numericItem(0)
),
  title="Change x to be able to close",
  buttons="Close",
  Close_handler=function(.) {
    if(.$get_x() != 0)
      .$close_gui()
  })
dlg$make_gui()
```

If a button name has spaces or other non-alpha characters, they are stripped before calling the handler. For example, a button labeled "Click me" would call the handler `Clickme_handler`.

The special button name "SPACE" will insert a 10 pixel space. The special button name "SPRING" will insert a "spring" between the buttons.

4.3 Scope

The underlying `proto` package treats methods differently than may be expected. In particular, sometimes lookup for a variable happens in a different place than expected. For example:

```
fun <- function() {
  a <- 1
  dlg <- aDialog(items=list(),
                 a=2,
                 meth1=function(.) a)
  dlg$meth2 <- function(.) a
  dlg[['meth3']] <- function(.) a
  c("1"=dlg$meth1(), "2"=dlg$meth2(), "3"=dlg$meth3())
}
fun()

1 2 3
1 2 1
```

In `meth1` and `meth2` the environment of passed in methods is the lexical environment, so the unbound variable `a` is found from the enclosing environment of `fun`, whereas in `meth3` the environment is that of the `proto` object `dlg`, which has the value of 2 defined for `a`. the moral here, is you likely want to use `[[<-` for assignment of new methods if done after the time of construction.

5 Views

Views provide a means to customize the look of a dialog or item group. A view is simply a container. The constructors specify the child components as either strings indicating items, or other views. A `context` allows the appropriate item to be found from the string. By default, this context is the calling dialog or item group, but need not be. This can be useful if the item to display is in another item group.

5.1 Types of views

The various views are described by their man pages. They are very similar to the `gWidgets` containers except for that provided by the `aContext` constructor. This view does not place its items in a container, but rather provides a means to specify a context. This is useful if an item comes from another item group, but you wish the alignment of the item to be as others.

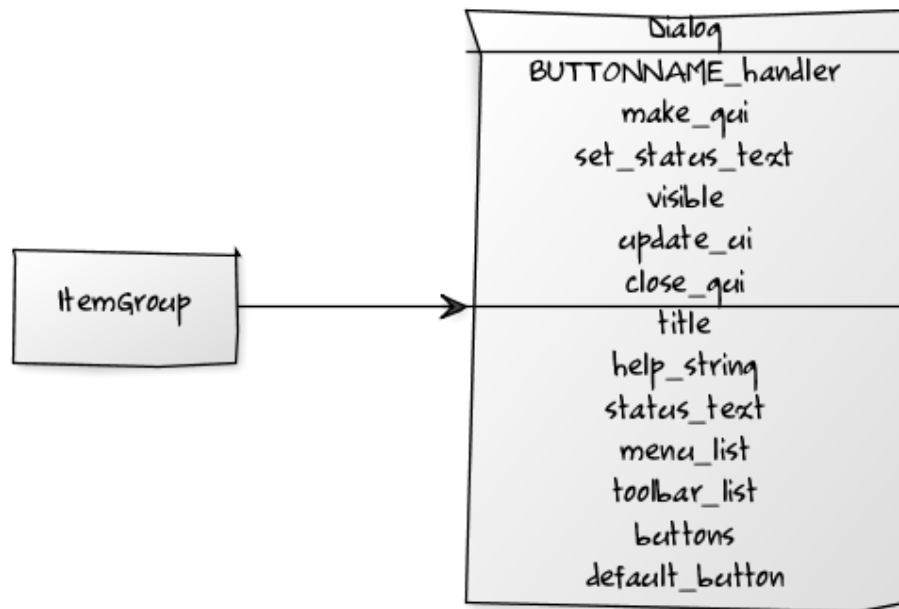


Figure 9: Standard methods and properties for a dialog.

Table 2: Table of view constructors.

Constructor	Description
<code>aContainer</code>	Basic container, uses tabular layout
<code>aTableLayout</code>	Tabular layout with more than 2 columns
<code>aGroup</code>	Box container to pack in children left to right or top to bottom
<code>aFrame</code>	Box container with decorative frame
<code>anExpandGroup</code>	Box container with trigger to hide
<code>aPanedGroup</code>	Two pane container
<code>aNotebook</code>	Notebook container
<code>aContext</code>	Provide context for an item or items

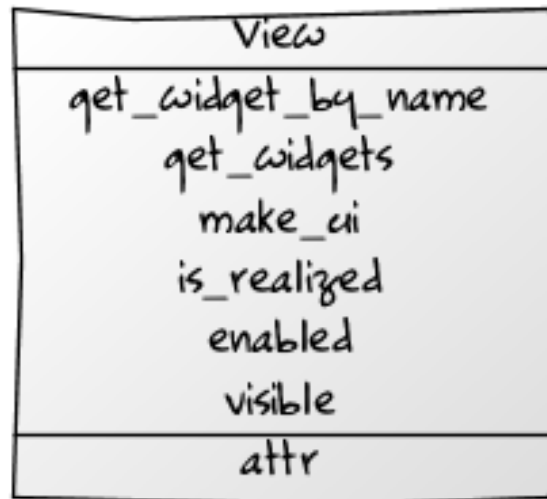


Figure 10: Standard methods and properties for a view.

5.2 Enabled and visible

In a previous example we illustrated the view method `enabled_when` which is called whenever a property value is changed. If this returns `FALSE`, then this part of the view has its sensitivity disabled.

Similarly, there is a `visible_when` method that can be used to hide a portion of a GUI until something occurs.

5.3 Editors

A view is used to layout one or more items, whereas each item itself has its interface produced by an editor. Editors are specified by the item constructor, with a default editor usually being appropriate. Some items provide more than one possible editor, for instance the `choiceItem`. To specify which editor to use, the property `editor_style` is set to the name of the different editor.

To define a new item, one must also provide an editor or use one of the existing ones.

5.4 Integration with gWidgets

The `gWidgets` package is used to provide the link between the `traitr` objects and a graphical toolkit package, such as `RGtk2`. In order to customize the appearance of the editors, one passes through the `attr` argument a list of values for `gWidgets` constructors.

To place a `traitr` GUI within a `gWidgets` GUI, one can use either the `make_ui` method of an item object, or the `make_gui` method of an itemgroup object, as both have a `container` argument to pass in a `gWidgets` container.

To place a `gWidgets` object within a `traitr` object is more difficult, as there is no API for this (yet). At this point, one can create a container object and place it within that. The container

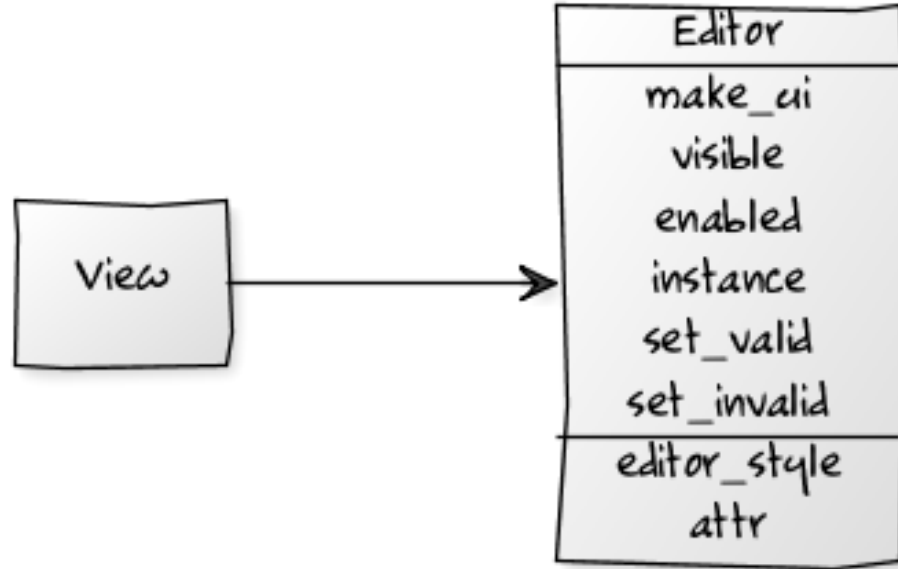


Figure 11: Standard methods and properties for an editor.

object has a property `container` that stores the `gWidgets` container needed. However, this isn't available until after the GUI has been drawn.

This idea is illustrated below:

```

dlg <- aDialog(items=list(x=numericItem(1)))
g <- aGroup()                                # define outside view to access later
view <- aContainer("x",g)
dlg$make_gui(gui_layout=view, visible=FALSE) # postpone showing, but create containers
l <- glabel("Look ma, a gWidgets label", cont = g$container) # how to find container
dlg$visible(TRUE)
  
```

5.5 Adding elements to an already drawn GUI

In `gWidgets`, and indeed only because it is a common feature of the graphical toolkits, one can add elements to a previously drawn GUI. In `gWidgets`, this is done through the `add` method of containers (although this is usually called indirectly in the containers construction).

However, to add to a GUI using `traitr` is not so direct. Using the previous idea though allows it to be done provided you provide a place where objects will be added in the GUI construction. This is implemented by hiding the visibility of the container through its `visible_when` method.

```

dlg <- aDialog(items=list(x=numericItem(0)))
g <- aGroup(visible_when=function(.) FALSE) # suppress showing
view <- aContainer("x", g)
dlg$make_gui(gui_layout=view)
  
```

```
## now to add to the GUI at g:
ig <- anItemGroup(list(y=stringItem("a string")))
ig$make_gui(container=g)
g$visible_when <- function(.) TRUE
dlg$update_ui()
```

The call to the `update_ui` method is also done whenever a value changes, but in this case we want it to be done immediately so the string item shows up.

6 Some examples

Some additional examples follow that are a bit more involved.

6.1 chooseCRANmirror

The function `chooseCRANmirror` provides a GUI for selecting a CRAN mirror, providing a table to choose the mirror from and a button to click once the selection is done. Here we give a slightly better alternative, with a bit more information and also connect to a double click event. The key function, `setCran`, is taken from the original with slight modification.

```
m <- getCRANmirrors(all = FALSE, local.only = FALSE)[,c(1,2,4)]
setCran <- function(.,...) {
  URL <- .$get_cran()
  repos <- getOption("repos")
  repos["CRAN"] <- gsub("/$", "", URL[1L])
  options(repos = repos)
  .$close_gui()
}
```

Now we define our model, and use the default view.

```
dlg <- aDialog(items=list(
  cran=choiceItem(value=NA, values=m,
    show_label=FALSE, # suppress label
    attr=list(chosencol=3, size=c(400,500)) #chosencol is URL one, not first
  ),
  title="Choose a CRAN Mirror",
  help_string="Click a mirror, then OK, or double click on mirror",
  OK_handler=setCran, # OK button click
  property_cran_value_changed=setCran # double click
)
dlg$make_gui()
```

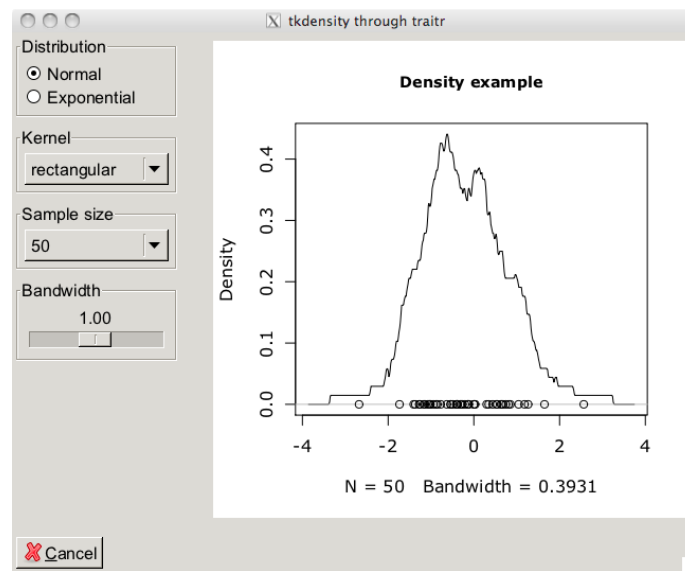


Figure 12: A dialog similar to that of the `tkdensity` demo in the `tcltk` package.

6.2 The `tkdensity` dialog

The `tkdensity` demo is a standard in the `tcltk` package. Here we redo the demo using `traitr` (Figure 12). This function will make the density plot for us, in a manner similar to that of the demo.

```
replot <- function(.) {
  l <- .$to_R()
  f <- function(dist, kernel, n, bw,...) {
    y <- switch(dist, "Normal"=rnorm(n), rexp(n))
    plot(density(y, bw=bw, kernel=kernel), xlim=range(y)+c(-2,2), main="Density example")
    points(y, rep(0,n))
  }
  do.call(f,l)
}
```

Here we define the items and the dialog properties. There are 5 main items, including the graphic device. The labels are suppressed, as we use a frame to set off similar to the original example.

```
dlg <- aDialog(items=list(
  dist=choiceItem("Normal", values=c("Normal", "Exponential"),
    show_label=FALSE),
  kernel=choiceItem("gaussian",
    values=c("gaussian", "epanechnikov", "rectangular",
      "triangular", "cosine"),
    show_label=FALSE),
```

```

n=choiceItem(50L, as.integer(c(50,100,200,300)),
  show_label=FALSE),
bw=rangeItem(value=1, from=0.05, to=2.00, by=0.05,
  show_label=FALSE),
out=graphicDeviceItem()
),
help_string="Adjust a parameter to update graphic",
title="tkdensity through traitr",
buttons="Cancel",
model_value_changed=replot)

```

Our layout places the controls on the left within frames, and the graphic device on the right. We use only the 'Cancel' button to match, somewhat, the demo.

```

view <- aGroup(aContainer(aFrame("dist", label="Distribution"),
  aFrame("kernel", label="Kernel"),
  aFrame("n", label="Sample size"),
  aFrame("bw", label="Bandwidth")
),
  "out",
  horizontal=TRUE)
dlg$make_gui(gui_layout=view)
replot(dlg)                                # initial plot

```

6.3 The `itemList` item

One of the drawbacks with this framework is that it is not geared around R's vectorized treatment of parameters and data. Although, the basic items, such as `numericItem`, can hold a vector of data, the editor for that is not helpful. The `itemList` item is used to get around this. It stores a list of items or itemgroups and has a means to edit on a per item basis. The basic usage depends on specifying how new items are to be constructed. The argument `item_factory` is where this is specified. Here are a few examples of it being used.

The most basic usage is to edit a vector of values, as here where the items are numeric.

```

i1 <- itemList(items=list(),
  items_names="x",
  item_factory=function(.) numericItem(0)
)
i1$make_ui(container=gwindow("Basic Use"))

```

NULL

If we add some items, we see that the `to_R` method will return a list of item values.

```

## add some items offline
for(i in 1:2) i1$append_item(i1$item_factory())

```



```
i1$to_R()

$Anonymous
$Anonymous$Anonymous
[1] 0

$Anonymous$Anonymous
[1] 0
```

If we want to make a data frame editor, we can do so as follows. Rather than have a single item, we have an item group to edit. The new `to_string` method is needed as this method gets called to label the table that shows the list of defined items. It should return a character vector of length 1.

```
i2 <- itemList(items=list(),
               items_names="Data frame rows",
               item_factory=function(.) {
                 ig <- anItemGroup(items=list(a=numericItem(0), b=stringItem("")))
                 ig$to_string <- function(.) .$get_b()
                 ig
               })
```

We provide a custom `to_R` method to take the output and place into a data frame. (Suggestions for a more elegant solution here are most welcome.)

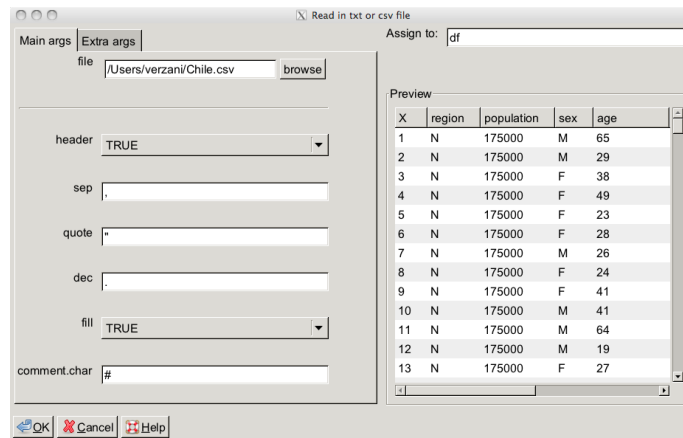
```
i2$to_R <- function(.) {
  items <- .$get_value()
  if(length(items) == 0) {
    out <- as.data.frame(.$item_factory()$to_R(), stringsAsFactors=FALSE)[0,]
  } else {
    out <- as.data.frame(items[[1]]$to_R(), stringsAsFactors=FALSE)
    if(length(items) > 1) {
      for(i in 2:length(items))
        out[i,] <- items[[i]]$to_R()
    }
  }
  out
}
```

And the basic call:

```
i2$make_ui(container=gwindow("Basic Use to make data frame"))
```

```
NULL
```

Finally, the manual page's example illustrates the `post_process` method call and how to add in icons to the item list.

Figure 13: A GUI for the `read.csv` and `read.table` functions.

6.4 A GUI for `read.csv` and `read.table`

This example shows how the mapping between argument and `traitr` items proceeds in a straightforward manner. We provide a GUI (Figure 13) for `read.csv` and `read.table`. While these both work quite easily with the default arguments, in the case they don't the arguments can be numerous. This GUI allows one to specify the arguments (except for typing in names and class types, although that could have been implemented using `stringItems` which evaluate their argument first).

First, the model part:

```
dlg <- aDialog(items=list(
  file=fileItem("", attr=list(
    filter=list("CSV or TXT"=list(
      patterns=c("*.csv", "*.txt")
    ),
    "All files" = list(patterns=c("*"))
  )),
  header=trueFalseItem(TRUE, tooltip=paste("Variable on first line?")),
  sep=stringItem("", tooltip="Field separator character"),
  quote=stringItem("", tooltip="Set of quoting characters"),
  dec=stringItem(".", tooltip="Character used for decimal points"),
  as.is=trueFalseItem(!default.stringsAsFactors(),
    tooltip="Do not convert character to factor"),
  na.strings=stringItem("NA", tooltip="Strings to be NA", eval=TRUE),
  nrows=integerItem(-1, tooltip="Max number of rows to read"),
  skip=integerItem(0, tooltip="Number of lines to skip at header"),
  check.names=trueFalseItem(TRUE, tooltip="If TRUE ensure names are valid"),
  fill=trueFalseItem(TRUE, tooltip="Fill unequal length rows if TRUE"),
  strip.white=trueFalseItem(TRUE),
  blank.lines.skip=trueFalseItem(TRUE, tooltip="If TRUE, skip blank lines"),
```

```

    comment.char=stringItem("#", tooltip="Comment character"),
    allowEscapes=trueFalseItem(TRUE, tooltip="C-style escapes read verbatim?"),
    stringsAsFactors=trueFalseItem(default.stringsAsFactors(),
    tooltip="Characters converted to factors"),
    fileEncoding=stringItem(""),
    encoding=stringItem("unknown"),
    ## our things
    assign.to=stringItem("df", label="Assign to:"),
    output=tableItem(attr=list(size=c(400,400)), show_label=FALSE),
    file.type=stringItem("")
  ),
  title="Read in txt or csv file",
  help_string="Select a file, then adjust parameters."
)

```

The `file` object has `gWidgets` arguments passed through to filter which files are displayed. Otherwise, this is a straightforward mapping of arguments to type. The last three are there for the GUIs usage.

The view separates out the main arguments from some secondary ones, using the notebook container; and provides a place for the assignment and preview features. Above, we manually set the size in the `output` object above, as it does not gracefully allocate enough size to itself when the `gWidgetsRGtk2` backend is used.

```

view <- aGroup(aNotebook(
  aNotebookPage("file",
    separatorItem(),
    "header", "sep", "quote",
    "dec", "fill", "comment.char",
    label="Main args"),
  aNotebookPage("as.is", "na.strings", "nrows", "skip",
    "check.names", "fill", "strip.white", "blank.lines.skip",
    "allowEscapes", "stringsAsFactors",
    separatorItem(),
    "fileEncoding", "encoding",
    label="Extra args")
  ),
  aContainer("assign.to",
    aFrame("output", label="Preview")
  ),
  horizontal=TRUE)

```

The main function called to update the UI is this one, which checks the file type, then reads in the file using either `read.csv` or `read.table`. If successful, it returns the data frame.

```

dlg$read_file <- function(., file.type, output, assign.to, ...) {
  if(file.type != "") {

```

```

    out <- try(do.call(sprintf("read.%s",file.type), list(...)), silent=TRUE)
    if(inherits(out, "try-error")) {
      cat("Error reading file of type,", file.type, "\n")
      out <- data.frame(V1="")
    }
  } else {
    out <- data.frame(V1="")
  }
  return(out)
}

```

To integrate the `read_file` method, we set up the following handler for control:

```

dlg$model_value_changed <- function(.) {
  fname <- .get_file()
  if(file.exists(fname)) {
    for(i in c("txt","csv")) {
      if(grepl(paste("\\.",i,sep=""), fname))
        .set_file.type(c(txt="table",csv="csv")[i])
    }
  }
  switch(.get_file.type(),
    "csv"={.set_sep(","); .set_quote('"')},
    "table"={},
    {}
  )
  .set_output(.do_call("read_file",.to_R()))
}

```

This method sets up a call to our `read_file` using the values found from the `to_R` method. The use of `do_call` is identical to the familiar `do.call` function, except it gracefully handles the instance where the method does not exist.

This method is called whenever a model value is changed, even the `output` value, say, which is not really necessary. If this inefficiency bothers you, a different manner is presented at the end.

Finally, we change the default `OK_handler` to output the value to the given name. We use a `gWidgets` call to `gconfirm` to avoid overwriting a variable name without permission.

```

dlg$OK_handler <- function(.) {
  out <- .do_call("read_file",.to_R())
  assign.to <- .get_assign.to()
  if(exists(assign.to, envir=.GlobalEnv)) {
    if(!gconfirm(sprintf("Overwrite variable %s?", assign.to)))
      return()
  }
  assign(assign.to, out, envir=.GlobalEnv)
}

```

The GUI is drawn as usual now:

```
dlg$make_gui(gui_layout=view)
```

To see one way to get the dialog to update only in response to the appropriate changing of the model, we could replace the `model_value_changed` code with the following. First we have a different response when the file is changed, as we need to find the file type and adjust some arguments for CSV files.

```
dlg$property_file_value_changed <- function(., value, old_value) {
  if(file.exists(value)) {
    for(i in c("txt","csv")) {
      if(grepl(paste("\\\\.",i,sep=""), value))
        .set_file.type(c(txt="table",csv="csv")[i])
    }
  }
  switch(.get_file.type(),
    "csv"={.set_sep(","); .set_quote('"')},
    "table"={.set_output(.do_call("read_file",.to_R()))},
    {}
  )
}
```

The call to `set_output` will be done by both `set_sep` and `set_quote` as well, so we don't repeat more than we have to.

Now to update the preview when an argument is changed, we set up the appropriate `property_XXX_value_changed` methods, as follows:

```
nms <- names(dlg$get_items())
nms <- setdiff(nms, c("file","file.type","assign.to","output"))
QT <- sapply(nms, function(i) {
  assign(sprintf("property_%s_value_changed",i),
    function(., ...) {
      .set_output(.do_call("read_file",.to_R()))
    },
    envir=dlg)
})
```

The assignment of the method within the environment takes advantage of `proto` objects being environments.

6.5 A view data frame by row GUI

A common GUI for viewing data on web sites basically shows each row of a data frame as editable data. In statistics terms, we scroll through the cases in a data set. Below, we leave the editable part as an exercise, but show how the method `set_model` can be used to effect this type of GUI.

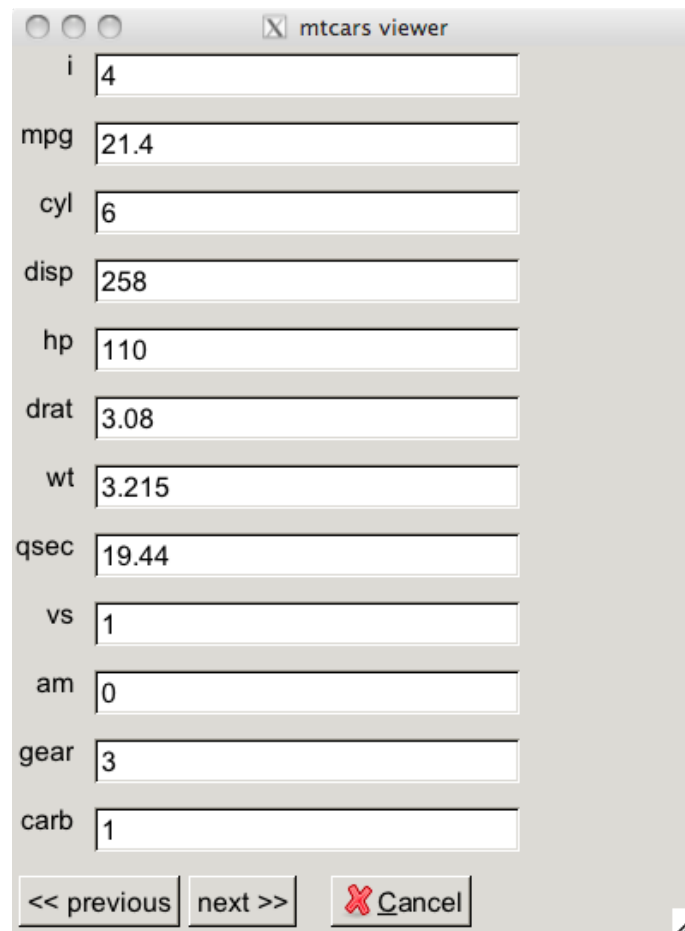


Figure 14: A GUI to scroll through the rows of a data frame.

This function creates a list of items from a row in the data frame. The `set_model` method for a dialog takes a dialog or item group for an argument. The output of this function will provide the items value.

```
m <- mtcars
nms <- names(m)
make_model <- function(i) {
  l <- list(i = integerItem(i))
  for(j in 1:ncol(m)) {
    l[[nms[j]]] <- numericItem(m[i,j])
  }
  l
}
```

Here we initialize the dialog and make two buttons to scroll through the rows. The `set_row` method finds the next row to show, then creates an item group which is used for our new model. The same extractor method, `get_i` is used in the button handlers.

```
dlg <- aDialog(items=make_model(1),
  title="Data frame scroller",
  help_string="Press buttons to scroll through data set",
  buttons=c("<< previous", "next >>", "SPACE", "Cancel"),
  set_row=function(.,i) {
    if(i < 1)
      i <- nrow(m)
    if(i > nrow(m))
      i <- 1
    ig <- make_model(as.numeric(i))
    .$set_model(anItemGroup(items=ig))
  },
  previous_handler=function(.) {
    i <- as.integer(.$get_i())
    .$set_row(i-1)
  },
  next_handler=function(.) {
    i <- .$to_R()$i      # same but different
    .$set_row(i + 1)
  })
```

We now make the GUI (Figure 14).

```
dlg$make_gui()
```

That's it. We leave for later perhaps using a scroller to scroll through the rows, or a means to edit the values and store in the data frame.

6.6 A Wizard GUI

A wizard, or multi-page dialog is a common GUI arrangement. Here is one way to implement such a feature, maybe not the best. We create a model to store our values and use instances of this model and views to show just part.

```
model <- aDialog(items=list(
  a=stringItem(""),
  b=stringItem("")
)
)
dlg1 <- aDialog(buttons="Next",
  Next_handler=function(.) {
    dlg2$make_gui(gui_layout=view2)
    .$close_gui()
  })
view1 <- aContainer("a", context=model)
dlg2 <- aDialog(buttons = c("Finished"),
  Finished_handler = function(.) {
    print(model$to_R())
    .$close_gui()
  })
view2 <- aContainer("b", context=model)
dlg1$make_gui(gui_layout=view1)
```

6.7 A "spotfire" like demo

The purveyor of S-Plus has a product to create interactive web pages from within S-Plus. See <http://spotfire.tibco.com> for details. The examples shown are of a similar type. A GUI is constructed around a specific data set and has some graphic to summarize the data and some filter controls to filter the display of the data. Additionally, there is some interactivity between the graphic and the data table. The latter we don't illustrate below, but we do illustrate how to use `traitr` to make a similar type of GUI.

This example will also demonstrate how one can create components with `traitr` to be used within other parts of a GUI.

The Spotfire demos all have a description page. Here illustrate how PANGO markup can be used with a label item to provide some markup for the instructions.

```
theDesc <- paste("<b>Spotfire</b>",
  "The Spotfire web player (http://spotfire.tibco.com)",
  "has several demos built around a somewhat similar set-up:",
  "a description page, a data set, a graphic display of the data, and a set",
  "of controls to filter out the data that is being displayed in the graphic.",
  "",
  "This example shows how <b>traitr</b> can be used to make a simple version of such",
  "",
```

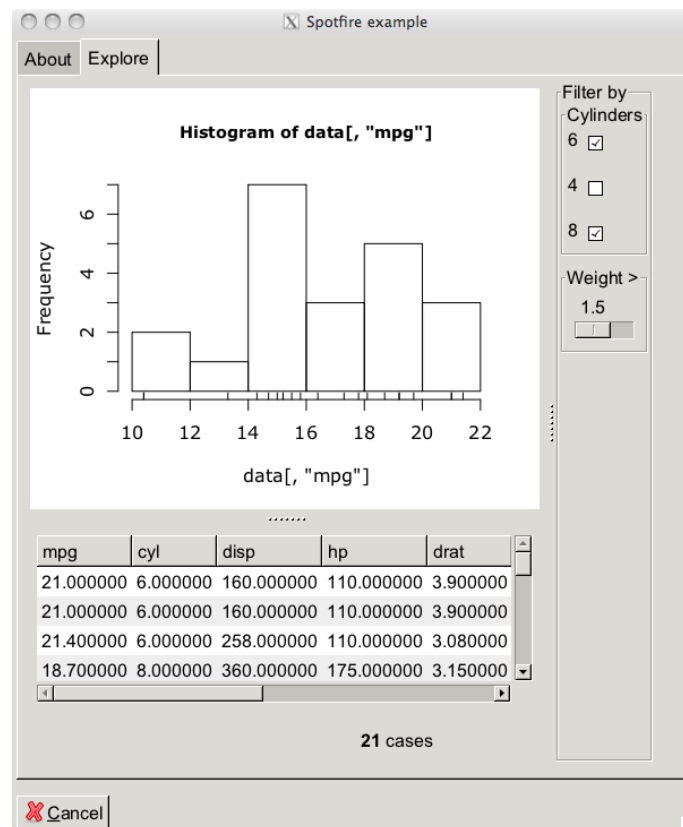



Figure 15: A GUI designed around the graphical summary of a data frame with controls to narrow the values displayed.

```
"Click the <i>Explore</i> tab to begin.",
sep="\n")
```

The data set we will use here is the standby `mtcars` one. This would be customized to the GUI in question. Our table display will also include a label to display the number of selected cases (rows) after filtering has occurred.

```
theData <- mtcars
makeLabel <- function(nr) sprintf("<b>%s</b> cases",nr)
dataDisplay <- anItemGroup(items=list(
  data = tableItem(theData, name="data", attr=c(expand=TRUE)),
  label = labelItem(makeLabel(nrow(theData)), attr=c(markup=TRUE, expand=
  ),
  attr=c(expand=TRUE)
)
```

We define this handler to synchronize the label with the size of the data being displayed.

```
## synchronize labe with data dimension
dataDisplay$property_data_value_changed <- function(., value, old_value)
  .$set_label(makeLabel(nrow(. $get_data()))))
```

We wish to specify the layout for the data table here, rather than in a monolithic specification when the entire GUI is constructed. By doing so, we could reuse this in other GUIs without much fuss. To do so, we redefine the method to define the default layout.

```
dataDisplay$make_default_gui_layout <- function(.) {
  aGroup("data",
    aGroup(labelItem("", attr=c(expand=TRUE)), "label", horizontal=TRUE),
    horizontal=FALSE)
}
```

Our filter controls are chosen to illustrate how we could use a slider or a checkbox to narrow the number of cases displayed.

We begin with a filter to narrow down by levels of a variable. The `get_selected` method returns a logical vector of the cases that are selected. For this, we also specify a default layout. Together, this creates a component that can easily be incorporated into another item group.

```
var <- "cyl"
varLevels <- sort(unique(theData[, var]))
cylFilter <- anItemGroup(name=var,
  items=list(
    choice=choiceItem(varLevels, varLevels,
      by_index=FALSE, multiple=TRUE, show_label=FALSE)
  ),
  data=theData[, var],
  get_selected = function(.) {
```

```

        choice <- .$.get_item_by_name("choice")
        value <- choice$.get_choice()
        values <- choice$.get_values()
        vals <- values[values %in% value]
        $.data %in% vals
      },
      make_default_gui_layout=function(.) {
        aFrame("choice", label="Cylinders")
      })

```

This shows a filter for a numeric variable.

```

var1 <- "wt"
rng <- range(theData[, var1])
wtFilter <- anItemGroup(name=var1,
  items=list(
    weight=rangeItem(value=rng[1] - .2, from=rng[1], to=rng[2], by=.2,
      show_label=FALSE, label="Weight >")
  ),
  data=theData[,var1],
  get_selected=function(.) {
    $.data >= $.to_R()$weight
  },
  make_default_gui_layout=function(.) {
    aFrame("weight", label="Weight > ")
  }
)

```

Our `filters` item group will hold the two. Here we specify the layout using a frame.

```

filters <- anItemGroup(items=list(cylFilter, wtFilter))
filters$make_default_gui_layout <- function(.) {
  aFrame(var,
    var1,
    label="Filter by",
    attr=c(size=c(300,-1)))
}

```

Our main method is called when a filter value is changed. It computes the indices of the cases that are still valid. This task is made simpler by defining the `get_selected` methods, as these return the logical values we wish.

```

filters$model_value_changed <- function(.) {
  items <- .$.get_items()
  ind <- as.logical(items[[1]]$.get_selected() * items[[2]]$.get_selected())
  dlg$update_data(ind)
}

```

With the pieces above, creating the main GUI is now straightforward. The items are four in number: the label, the data, the graphic device and the filter area.

```
dlg <- aDialog(items=list(
  Description=labelItem(theDesc, attr=c(markup=TRUE)),
  gd = graphicDeviceItem(),
  filters,
  dataDisplay
),
title="Spotfire example",
buttons="Cancel"
)
```

When the data is changed, we want the graphic to be updated.

```
dlg$property_data_value_changed <- function(., value, old_value)
  .draw_graphic()
```

This method was referred to above in the method calls for filtering. The filter updates the data, and then the above method is called to update the graphic.

```
dlg$update_data <- function(., index) {
  if(missing(index))
    data <- theData
  else
    data <- theData[index,]
  dataDisplay$set_data(data)
}
```

Finally, we make the drawing of the graphic a separate method, so we can call it without having to update the data set. We don't work very hard in the graphical summary of data.

```
dlg$draw_graphic <- function(.) {
  data <- dataDisplay$get_data()
  if(nrow(data)) {
    hist(data[, "mpg"])
    rug(data[, "mpg"])
  } else {
    plot.new()
  }
}
```

Finally, we use paned groups to layout our GUI, allowing the user to give more area to the data table if desired.

```
## Layout for main GUI
lyt <- aNotebook(aNotebookPage("Description",
  label="About"
```

```
    ),  
    aNotebookPage(aPanedGroup(  
      aPanedGroup("gd",  
        dataDisplay,  
        horizontal=FALSE),  
      filters),  
    label="Explore"  
  )  
)
```

Since the GUI takes a few seconds to load, we first call the `loadingAnimation` window to give the user some feedback.

```
w <- loadingAnimation()  
dlg$make_gui(gui_layout=lyt)  
w$close()
```