Getting started with palmsplusr

Tom Stewart

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Loading the PALMS dataset

A PALMS dataset (in csv format) is read in using the `read_palms()` function. This function checks that all required column names are present before converting the csv file to a simple features (spatial) object. If any columns are missing you will receive an error message. For a list of required column names, please see the `read_palms()` help file. This example will use the data built into this package, which has been collected from one participant.

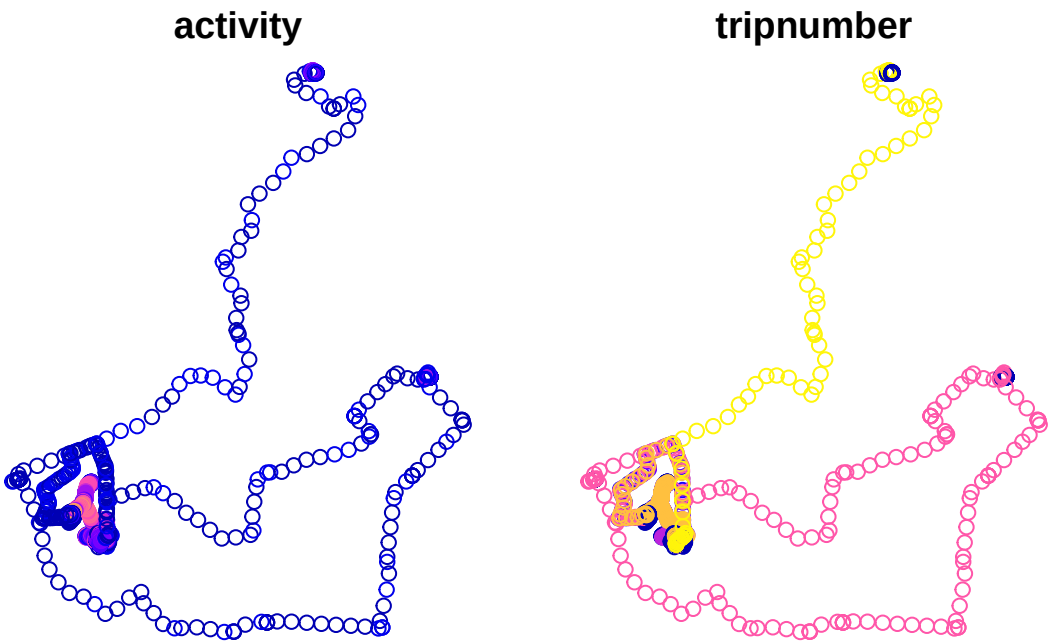
```
library(palmsplusr)

palms <- read_palms(system.file("extdata", "one_participant.csv", package = "palmsplusr"))
names(palms)
```

```
##  [1] "identifier"          "datetime"            "dow"
##  [4] "fixtypecode"         "iov"                 "tripnumber"
##  [7] "triptype"            "tripmot"             "activity"
## [10] "activityintensity"   "activityboutnumber"  "sedentaryboutnumber"
## [13] "geometry"
```

This `palms` object contains 13 columns. Notice how the `lon` and `lat` columns that were present in the csv have been replaced by a `geometry` column. This is POINT geometry, as each row in `palms` represents a point. You can plot this data to look at the distribution of points in space. Here two columns are plotted:

```
plot(palms[, c("activity", "tripnumber")])
```



Building palmsplus

The palmsplus build process adds additional columns (i.e., *fields*) to the input `palms` dataset shown above. However, the user needs to specify what columns to add, and how to calculate them. This is done by creating a table with the name of the new column and the formula used to calculate it. In most cases, new fields are calculated from combinations of existing fields, but external data may also be used (see next section).

The function `palms_add_field(name, formula, domain_field = FALSE)` is used to add a field:

```
palms_add_field("weekday",    "dow < 6")
palms_add_field("weekend",    "dow > 5")
palms_add_field("indoors",    "iov == 3")
palms_add_field("outdoors",   "iov == 1")
palms_add_field("in_vehicle", "iov == 2")
palms_add_field("inserted",   "fixtypecode == 6")
palms_add_field("pedestrian", "tripmot == 1")
palms_add_field("bicycle",    "tripmot == 2")
palms_add_field("vehicle",    "tripmot == 3")
palms_add_field("nonwear",    "activityintensity < 0",  TRUE)
palms_add_field("wear",       "activityintensity >= 0", TRUE)
palms_add_field("sedentary",  "activityintensity == 0", TRUE)
palms_add_field("light",      "activityintensity == 1", TRUE)
palms_add_field("moderate",   "activityintensity == 2", TRUE)
palms_add_field("vigorous",   "activityintensity == 3", TRUE)
palms_add_field("mvpa",       "moderate + vigorous",    TRUE)
```

Note this is for the purpose of demonstration, as the code above can be replicated using `palms_load_defaults()`. The third parameter, `domain_field`, specifies whether the field should be summarized when creating the `days` dataset (see Building days below for more info).

Each time you add a new field, a new row is appended to the `palmsplus_fields` table. This table is automatically created in the global environment when adding fields. If this table is printed, you will see it contains the fields that were just added:

```
palmsplus_fields
```

Table 1: palmsplus_fields

name	formula	domain_field
weekday	dow < 6	FALSE
weekend	dow > 5	FALSE
indoors	iov == 3	FALSE
outdoors	iov == 1	FALSE
in_vehicle	iov == 2	FALSE
inserted	fixtypecode == 6	FALSE
pedestrian	tripmot == 1	FALSE
bicycle	tripmot == 2	FALSE
vehicle	tripmot == 3	FALSE
nonwear	activityintensity < 0	TRUE
wear	activityintensity >= 0	TRUE
sedentary	activityintensity == 0	TRUE
light	activityintensity == 1	TRUE
moderate	activityintensity == 2	TRUE
vigorous	activityintensity == 3	TRUE
mvpa	moderate + vigorous	TRUE

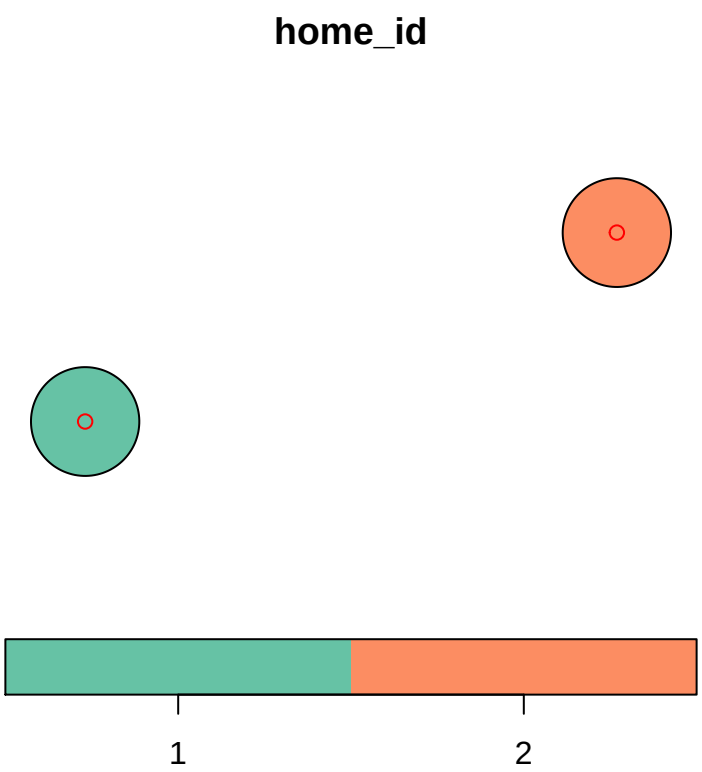
Using external data

Any variable from the `palms` dataset can be used to build formulas, although the true power of **palmsplusr** comes from integrating external data into these calculations.

In the code below, a shapefile that represents home points is read in and buffered by 100 m to create polygons. These polygons are going to be used in a field formula. When this data is plotted, you will notice this person has two homes:

```
home.points <- read_sf(system.file("extdata/shapefiles/", "home.shp", package = "palmsplusr"))
home.buffer <- palms_buffer(point = home.points, distance = 100)

# Plot
plot(home.buffer[, "home_id"], key.pos = 1)
plot(home.points[, "home_id"], col = "red", add = TRUE)
```



Below, these polygon data are used to create a new field called *at_home*. The purpose of this field is to identify any `palms` point that fall inside these home.buffer polygons. This information is later used to determine the time spent at home each day, and even identify trips that start or end at home. The formula for this field uses the `palms_in_polygon()` helper function. For a more detailed explanation about helper functions and creating formulas in general, please see the building formulas article.

```
palms_add_field("at_home", "palms_in_polygon(., home.buffer, identifier)")
```

Once all of the fields have been added, you can build the `palmsplus` dataset using the `palms_build_palmsplus()` function. This takes the `palms` dataset as input:

```
palmsplus <- palms_build_palmsplus(palms)
```

```
## [1/1] Computed palmsplus for: BC0627
```

When printing the column names of the `palmsplus` dataset, you will notice it contains 30 columns: the original 13 in `palms` plus the 17 that were added as fields:

```
names(palmsplus)
```

```
##  [1] "identifier"          "datetime"            "dow"
##  [4] "fixtypecode"         "iov"                 "tripnumber"
##  [7] "triptype"            "tripmot"             "activity"
## [10] "activityintensity"   "activityboutnumber"  "sedentaryboutnumber"
## [13] "weekday"             "weekend"             "indoors"
## [16] "outdoors"            "in_vehicle"          "inserted"
## [19] "pedestrian"          "bicycle"             "vehicle"
## [22] "nonwear"             "wear"                "sedentary"
## [25] "light"               "moderate"            "vigorous"
## [28] "mvpa"                "at_home"             "geometry"
```

Now that the `palmsplus` dataset is built, it can be summarized in two ways: building days, or building trajectories.

Building days

The `days` dataset provides a daily summary of the `domain_fields` present in the `palmsplus` dataset. Recall the `domain_fields` in the dataset above were:

- nonwear
- wear
- sedentary
- light
- moderate
- vigorous
- mvpa

These fields are summarized across several **domains**, which can be thought of as temporal or spatial subsets of a 24-hour day. Examples domains are: *during work hours*, *in greenspace*, *at home*, *in the town centre on weekends*.

Each of the `domain_fields` are summarized separately for each domain. By default, a *total* domain is used, which summarizes all data within each 24-hour period. Any additional domains need to be specified by the user.

Two additional domains are added below: *home* and *transport*. All `palmsplus` points that meet the `at_home` criteria (the field added above) will be added to the *home* domain. All `palmsplus` points that meet the `pedestrian` or `bicycle` or `vehicle` criteria (also fields added above) will be assigned to the transport domain. Domains are added the same way fields are added:

```
palms_add_domain("home", "at_home")
palms_add_domain("transport", "!home & (pedestrian | bicycle | vehicle)")
```

```
palmsplus_domains
```

Table 2: palmsplus_domains

name	formula
home	at_home
transport	!home & (pedestrian | bicycle | vehicle)

It is important to note that formulas are evaluated in the order they are specified, so one formula can contain another field name, as seen with the `!home` (not home) in transport domain formula above.

Now that additional domains have been added, the `palms_build_days()` function can be used to build `days` from the `palmsplus` dataset:

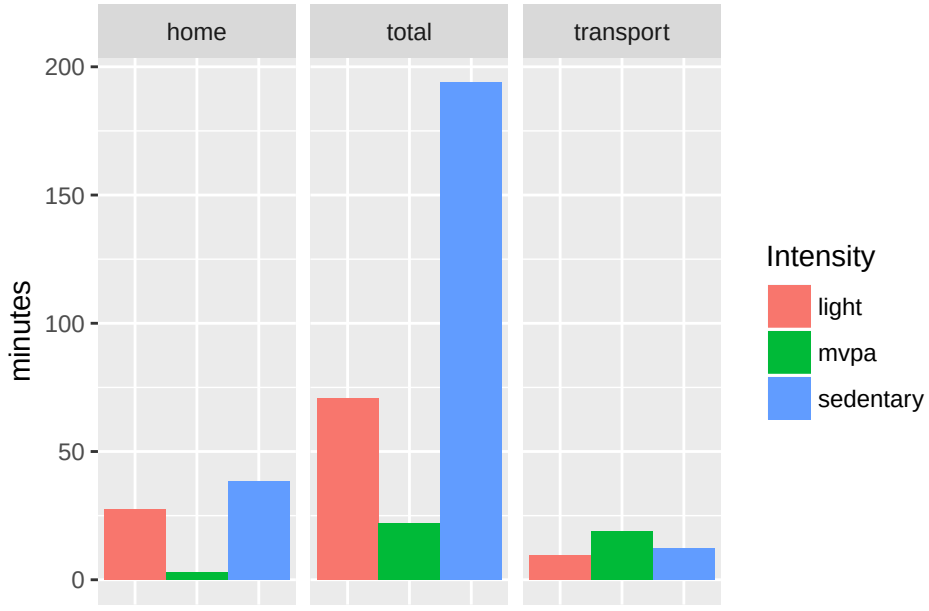
```
days <- palms_build_days(palmsplus)
```

When looking at the structure of the `days` dataset, you will notice the `domain_fields` have been summarized for each domain. Note that the ***total domain*** and the ***duration field*** are included by default.

```
str(days)
```

```
## Classes 'tbl_df', 'tbl' and 'data.frame':    9 obs. of  26 variables:
##  $ identifier         : chr  "BC0627" "BC0627" "BC0627" "BC0627" ...
##  $ date               : Date, format: "2013-08-26" "2013-08-27" ...
##  $ total_nonwear      : num  344 954 501 354 1306 ...
##  $ total_wear         : num  427 486 557 0 134 ...
##  $ total_sedentary    : num  273 328 388 0 49 ...
##  $ total_light        : num  101 120.2 126.8 0 81.2 ...
##  $ total_moderate     : num  31 25 26.75 0 4.25 ...
##  $ total_vigorous     : num  22 13.2 15.8 0 0 ...
##  $ total_mvpa         : num  53 38.25 42.5 0 4.25 ...
##  $ total_duration     : num  771 1440 1058 354 1440 ...
##  $ home_nonwear       : num  344 871 501 354 1306 ...
##  $ home_wear          : num  4.5 58 150.2 0 134.5 ...
##  $ home_sedentary     : num  0 41.2 102.5 0 49 ...
##  $ home_light         : num  2.5 13.8 41.5 0 81.2 ...
##  $ home_moderate      : num  0.75 3 4.5 0 4.25 4.5 0.75 1.25 1.25
##  $ home_vigorous      : num  1.25 0 1.75 0 0 0 0.25 1 0.25
##  $ home_mvpa          : num  2 3 6.25 0 4.25 4.5 1 2.25 1.5
##  $ home_duration      : num  348 929 652 354 1440 ...
##  $ transport_nonwear  : num  0 0 0 NA NA 0 NA 0 0
##  $ transport_wear     : num  46 38.5 40.2 NA NA ...
##  $ transport_sedentary: num  2 5.25 4.25 NA NA 34 NA 6 22.5
##  $ transport_light    : num  13.5 8.25 13.75 NA NA ...
##  $ transport_moderate : num  15.8 14.8 13 NA NA ...
##  $ transport_vigorous : num  14.75 10.25 9.25 NA NA ...
##  $ transport_mvpa     : num  30.5 25 22.2 NA NA ...
##  $ transport_duration : num  46 38.5 40.2 NA NA ...
```

A summary plot of activity intensities for each domain, using these data:



Building trajectories

The `trajectories` dataset contains individual trips, and trip-level summaries. Fields that you wish to calculate for each trajectory can be specified with `palms_add_trajectoy_field(name, formula, after_conversion = FALSE)`. The data passed to trajectory formulas are all of the `palmsplus` points that have the same `tripnumber` (i.e., belong to the same trip).

```
epoch <- palms_epoch(palms)

palms_add_trajectory_field("mot",       "first(tripmot)")
palms_add_trajectory_field("date",      "first(as.Date(datetime))")
palms_add_trajectory_field("start",     "datetime[triptype==1]")
palms_add_trajectory_field("end",       "datetime[triptype==4]")
palms_add_trajectory_field("duration",  "as.numeric(difftime(end, start, units = \"secs\") + epoch)")
palms_add_trajectory_field("nonwear",   "sum(activityintensity < 0) * epoch")
palms_add_trajectory_field("wear",      "sum(activityintensity >= 0) * epoch")
palms_add_trajectory_field("sedentary", "sum(activityintensity == 0) * epoch")
palms_add_trajectory_field("light",     "sum(activityintensity == 1) * epoch")
palms_add_trajectory_field("moderate",  "sum(activityintensity == 2) * epoch")
palms_add_trajectory_field("vigorous",  "sum(activityintensity == 3) * epoch")
palms_add_trajectory_field("mvpa",      "moderate + vigorous")
palms_add_trajectory_field("length",    "as.numeric(st_length(.))",  TRUE)
palms_add_trajectory_field("speed",     "(length / duration) * 3.6", TRUE)
```

Notice the `palms_epoch()` helper function is used here, and the epoch length is used in some formulas. This is so the output is in seconds, rather than a row count.

Similar to above, these example trajectory fields are the default fields, and can be built with the `palms_load_defaults()` function. Note that an epoch length must be supplied so the formulas are built correctly: `palms_load_defaults(palms_epoch(palms))`.

Because `trajectories` are built from the `palmsplus` dataset, any variables used in the trajectory field formulas should be present in the `palmsplus` dataset.

```
trajectory_fields
```

Table 3: trajectory_fields

name	formula	after_conversion
mot	first(tripmot)	FALSE
date	first(as.Date(datetime))	FALSE
start	datetime[triptype==1]	FALSE
end	datetime[triptype==4]	FALSE
duration	as.numeric(difftime(end, start, units = “secs”) + epoch)	FALSE
nonwear	sum(activityintensity < 0) * epoch	FALSE
wear	sum(activityintensity >= 0) * epoch	FALSE
sedentary	sum(activityintensity == 0) * epoch	FALSE
light	sum(activityintensity == 1) * epoch	FALSE
moderate	sum(activityintensity == 2) * epoch	FALSE
vigorous	sum(activityintensity == 3) * epoch	FALSE
mvpa	moderate + vigorous	FALSE
length	as.numeric(st_length(.))	TRUE
speed	(length / duration) * 3.6	TRUE

The `after_conversion` parameter dictates whether the fields are calculated before or after the trip points are converted to `LINESTRING` geometry. Some fields can only be calculated on `LINESTRING` objects, such as the length of the line (and by extension, speed).

The `palms_build_trajectories()` function is used to build trajectories from the `palmsplus` dataset:

```
trajectories <- palms_build_trajectories(palmsplus)
```

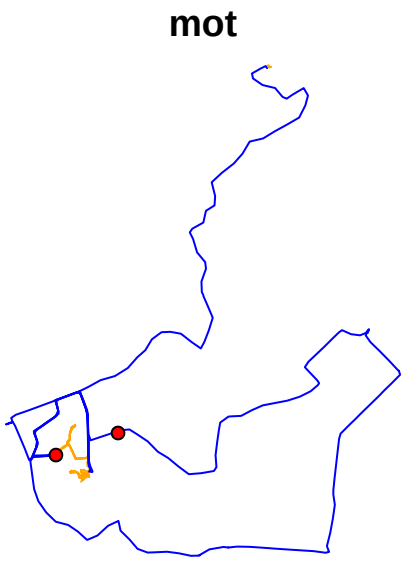
When looking at the structure of the `trajectories` dataset, you will notice it contains the fields created above, and `LINESTRING` geometry:

```
str(trajectories, give.attr = FALSE)
```

```
## Classes 'sf' and 'data.frame':   38 obs. of  17 variables:
##  $ identifier: chr  "BC0627" "BC0627" "BC0627" "BC0627" ...
##  $ tripnumber: int  1 2 3 4 5 6 7 8 9 10 ...
##  $ mot       : int  1 1 1 1 1 1 1 3 1 1 ...
##  $ date      : Date, format: "2013-08-26" "2013-08-26" ...
##  $ start     : POSIXct, format: "2013-08-26 11:08:45" "2013-08-26 13:29:45" ...
##  $ end       : POSIXct, format: "2013-08-26 11:11:30" "2013-08-26 13:32:15" ...
##  $ duration  : num  180 165 555 255 675 1230 555 480 165 225 ...
##  $ nonwear   : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ wear      : num  180 165 555 255 675 1230 555 480 165 225 ...
##  $ sedentary : num  30 0 60 60 0 90 15 285 0 45 ...
##  $ light     : num  45 75 285 135 435 195 75 150 0 105 ...
##  $ moderate  : num  0 45 150 45 195 510 195 45 60 75 ...
##  $ vigorous  : num  105 45 60 15 45 435 270 0 105 0 ...
##  $ mvpa      : num  105 90 210 60 240 945 465 45 165 75 ...
##  $ length    : num  198 125 518 129 401 ...
##  $ speed     : num  3.97 2.74 3.36 1.82 2.14 ...
##  $ geometry  :sfc_LINESTRING of length 38; first list element:  XY [1:12, 1:2] 175 175 175 175 175 .
```

As the `trajectories` dataset contains `LINESTRING` geometry, it can be plotted. Below the trajectories are colored based on the `mot` column, and the home.buffer polygons are added to the plot:

```
plot(trajectories[, "mot"], pal = c("orange", "blue"), key.pos = NULL)
plot(home.buffer[, 1], col = "red", key.pos = NULL, add = TRUE)
```



Adding trajectory locations

Trajectory locations can also be calculated. These are used to identify specific trip start and end locations, such as trips from home to work or school. Trajectory locations are added with the function `palms_add_trajectory_location(name, start_criteria, end_criteria)`. If any trajectory locations have been added, they will automatically be calculated when `palms_build_trajectories()` is executed.

The `start_criteria` and `end_criteria` parameters should be fields already calculated in `palmsplus`.

To demonstrate, all trajectories that start at home and end at school will be identified. To do this, an additional shapefile that contains the schoolyard polygon is read in, and add a new *at_school* field is added to `palmsplus`.

```
school <- read_sf(system.file("extdata/shapefiles/", "school.shp", package = "palmsplusr"))

palms_add_field("at_school", "palms_in_polygon(., school)")

palmsplus <- palms_build_palmsplus(palms)
```

```
## [1/1] Computed palmsplus for: BC0627
```

Now that `palmsplus` contains the *at_school* field, I'm going to add a `trajectory_location` that starts *at_home* and ends *at_school*. Recall the *at_home* field was created earlier.

```
palms_add_trajectory_location("home_school", "at_home", "at_school")
```

```
trajectory_locations
```

Table 4: trajectory_locations

name	start_criteria	end_criteria
home_school	at_home	at_school

Now the `trajectories` dataset can be rebuilt. Additional columns will be added for each entry in the `trajectory_locations` table indicating whether the trajectory meets both the start and end criteria.

```
trajectories <- palms_build_trajectories(palmsplus)
names(trajectories)
```

```
##  [1] "identifier"  "tripnumber"  "mot"         "date"        "start"
##  [6] "end"         "duration"    "nonwear"     "wear"        "sedentary"
## [11] "light"       "moderate"    "vigorous"    "mvpa"        "home_school"
## [16] "length"      "speed"       "geometry"
```

Notice how the `trajectories` dataset now contains a `home_school` column, which signifies whether the trip started at home and ended at school. In total, 4/38 trajectories meet this criteria:

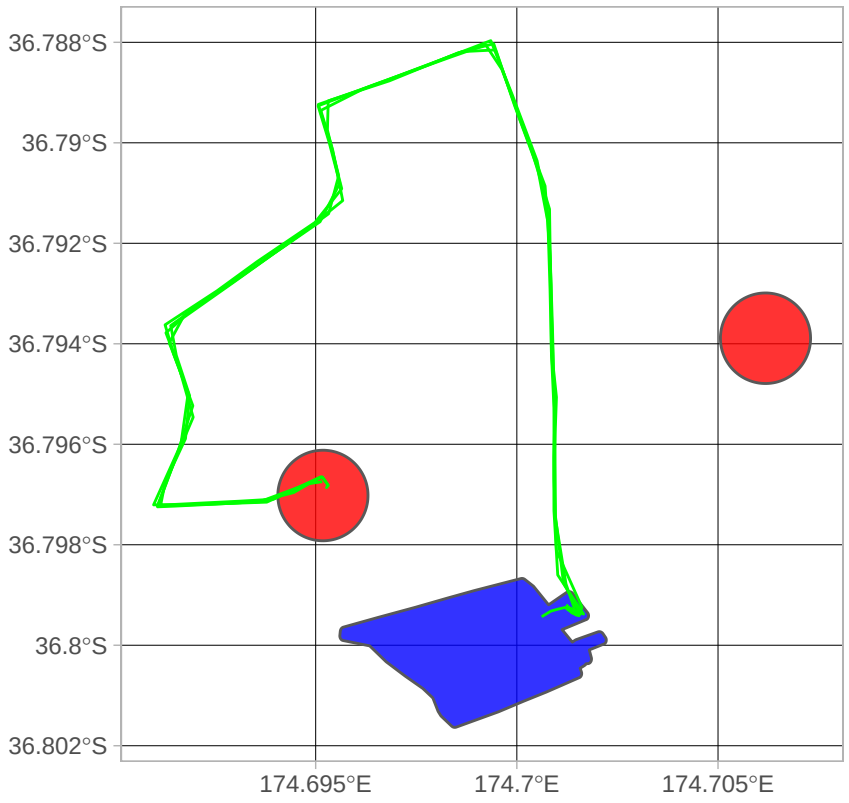
```
table(trajectories$home_school)
```

```
##
##  0  1
## 34  4
```

We can double check the results by plotting these trajectories. The ggplot2 package can also be used instead of R's base plot. Please see the article ggplot2 and palmsplusr for more informaiton.

```
library(ggplot2)

ggplot() +
  geom_sf(data=home.buffer, fill = "red", alpha = 0.8) +
  geom_sf(data=school, fill = "blue", alpha = 0.8) +
  geom_sf(data=trajectories %>% filter(home_school == 1), colour = "green") +
  theme_light()
```



It looks like all the trajectories where `home_school == 1` start at home and end at school.

Building multimodal trajectories

The `trajectories` dataset can be further processed into multimodal trips using the `palms_build_multimodal()` function. This will join two or more trajectories together if they are within a spatial and temporal threshold.

Multimodal trajectories are important, because PALMS assigns a new trip number each time the travel mode changes. A change in travel mode part way along a commute may mean none of the trip 'segments' meet the `start_criteria` and `end_criteria`.

This is also useful for identifying trip chains and transit use (e.g., walk-vehicle-walk), and joining trips where a long pause has occured.

The fields that are summarized for each multimodal trajectory are specified using `palms_add_multimodal_field(name, func)`.

The `name` refers to a field name in the `trajectories` dataset, while `func` specifies a summary function used to aggregate trajectory fields (usually `sum()` or `mean()`). For example, you probably want to sum the duration of multiple segments, but take the average (mean) of their speeds.

```
palms_add_multimodal_field("duration", "sum")
palms_add_multimodal_field("speed", "mean")
```

Alternatively, you can pass in a vector of field names that use the same summary function:

```
palms_add_multimodal_field(c("nonwear", "wear", "sedentary", "light", "moderate",
                             "vigorous", "mvpa", "length"), "sum")
```

```
multimodal_fields
```

Table 5: multimodal_fields

name	func
duration	sum
speed	mean
nonwear	sum
wear	sum
sedentary	sum
light	sum
moderate	sum
vigorous	sum
mvpa	sum
length	sum

It should be noted that these `multimodal_fields` are the default fields created by `palms_load_defaults()`.

The `trajectories` dataset is then passed to `palms_build_multimodal(spatial_threshold, temporal_threshold)` to build the `multimodal` dataset.

The `spatial_threshold` is the distance (in meters) between the end of one trajectory and the start of the next, while the `temporal_threshold` is the time between these (in minutes). This example uses a criteria of 200 m and 10 minutes:

```
multimodal <- palms_build_multimodal(trajectories, 200, 10)
```

```
## Calculating multimodal eligibility...done
## Assigning trip numbers...done
## Calculating fields...done
```

An important note is the `trajectories` dataset must contain the following columns, as multimodal eligibility cannot be assessed without them:

- identifier
- tripnumber
- start
- end
- geometry
- mot

When looking at the structure of the `multimodal` dataset, you will notice basic multimodal information, an overall summary for each field, and also for each travel mode (note this participant has no bicycle trips):

```
str(multimodal, give.attr = FALSE)
```

```
## Classes 'sf', 'tbl_df', 'tbl' and 'data.frame':  31 obs. of  39 variables:
##  $ identifier     : chr  "BC0627" "BC0627" "BC0627" "BC0627" ...
##  $ mmt_number     : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ trip_numbers   : chr  "1" "2" "3-4" "5-6" ...
##  $ n_segments     : int  1 1 2 2 1 2 1 1 1 1 ...
##  $ mot_order      : chr  "1" "1" "1-1" "1-1" ...
##  $ start          : POSIXct, format: "2013-08-26 11:08:45" "2013-08-26 13:29:45" ...
##  $ end            : POSIXct, format: "2013-08-26 11:11:30" "2013-08-26 13:32:15" ...
##  $ home_school    : int  0 0 0 0 0 1 0 0 0 0 ...
##  $ mot_1_duration : num  180 165 810 1905 555 ...
##  $ mot_1_length   : num  198 125 647 1620 625 ...
##  $ mot_1_light    : num  45 75 420 630 75 0 105 75 195 420 ...
##  $ mot_1_moderate : num  0 45 195 705 195 60 75 15 495 360 ...
##  $ mot_1_mvpa     : num  105 90 270 1185 465 ...
##  $ mot_1_nonwear  : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ mot_1_sedentary: num  30 0 120 90 15 0 45 0 90 15 ...
##  $ mot_1_vigorous : num  105 45 75 480 270 105 0 60 435 30 ...
##  $ mot_1_wear     : num  180 165 810 1905 555 ...
##  $ mot_3_duration : num  0 0 0 0 0 480 0 0 0 0 ...
##  $ mot_3_length   : num  0 0 0 0 0 ...
##  $ mot_3_light    : num  0 0 0 0 0 150 0 0 0 0 ...
##  $ mot_3_moderate : num  0 0 0 0 0 45 0 0 0 0 ...
##  $ mot_3_mvpa     : num  0 0 0 0 0 45 0 0 0 0 ...
##  $ mot_3_nonwear  : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ mot_3_sedentary: num  0 0 0 0 0 285 0 0 0 0 ...
##  $ mot_3_vigorous : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ mot_3_wear     : num  0 0 0 0 0 480 0 0 0 0 ...
##  $ duration       : num  180 165 810 1905 555 ...
##  $ nonwear        : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ wear           : num  180 165 810 1905 555 ...
##  $ sedentary      : num  30 0 120 90 15 285 45 0 90 15 ...
##  $ light          : num  45 75 420 630 75 150 105 75 195 420 ...
##  $ moderate       : num  0 45 195 705 195 105 75 15 495 360 ...
##  $ vigorous       : num  105 45 75 480 270 105 0 60 435 30 ...
##  $ mvpa           : num  105 90 270 1185 465 ...
##  $ length         : num  198 125 647 1620 625 ...
##  $ mot_1_speed    : num  3.97 2.74 2.59 2.85 4.06 ...
##  $ mot_3_speed    : num  NA NA NA NA NA ...
##  $ speed          : num  3.97 2.74 2.59 2.85 4.06 ...
##  $ geometry       :sfc_MULTILINESTRING of length 31; first list element: List of 1
##   ..$ : num [1:12, 1:2] 175 175 175 175 175 ...
```

Recall there were 38 observations in the `trajectories` dataset. We can see what trajectories were combined by looking at the `trip_numbers` variable:

```
multimodal$trip_numbers
```

```
##  [1] "1"        "2"        "3-4"      "5-6"      "7"        "8-9"
##  [7] "10"       "11"       "12"       "13"       "14-15"    "16"
## [13] "17"       "18"       "19"       "20"       "21"       "22"
## [19] "23"       "24"       "25"       "26"       "27"       "28"
## [25] "29"       "30"       "31"       "32"       "33-34"    "35"
## [31] "36-37-38"
```

The `mot_order` variable retains the mode of travel order of each multimodal trip:

```
multimodal$mot_order
```

```
##  [1] "1"     "1"     "1-1"   "1-1"   "1"     "3-1"   "1"     "1"
##  [9] "1"     "1"     "3-1"   "1"     "1"     "1"     "1"     "1"
## [17] "1"     "3"     "3"     "3"     "3"     "1"     "1"     "1"
## [25] "1"     "1"     "1"     "1"     "3-1"   "1"     "1-3-1"
```

If any `trajectory_locations` were created, they will also be added to `multimodal` (notice the *home_school* field in the `multimodal` structure above).

Saving geometry and results

You can save all datasets as a csv file. The `palmsplus`, `trajectories` and `multimodal` datasets can be saved as ESRI shapefiles as they contain geometry:

```
write_csv(palmsplus, "palmsplus.csv")
write_csv(days, "days.csv")
write_csv(trajectories, "trajectories.csv")
write_csv(multimodal, "multimodal.csv")

st_write(palmsplus, "palmsplus.shp")
st_write(trajectories, "trajecories.shp")
st_write(multimodal, "multimodal.shp")
```