river_connection_directional

Load Libraries

```
library(sfnetworks)
library(sf)
library(tidygraph)
library(dplyr)
library(purrr)
library(TSP)
```

Load data

```
trial_river <- readRDS(here::here("data", "cleaned", "trial_river_cleaned.rds"))
```

Transform data to `sfnetwork` type and calculates edge weights

- Spatial networks have 2 data tables:
  - Nodes (junctions/endpoints)
  - Edges (line connecting points)
- Create another column: \`weight\` for river segment *distance*
- `direction = TRUE` means flow can only do in the direction the line geometeries are drawn (downstream only). Should align with flow direction in HydroRIVERS
  - df's `next_down` - each segment points to its downstream neighbor
  - **For downstream-only paths: This now enforces that paths only follow the direction of line geometries (downstream). A path from upstream→downstream will work, but downstream→upstream won't find a route.**

```
net <- as_sfnetwork(trial_river, direction = TRUE) %>% # convert river geom into spatial
  activate("edges") %>%  # "Next operation applied to edges table (not node table)"
  mutate(weight = edge_length()) # calculate spatial length of each edge (river segment)


net_df <- as_tibble(net) # makes sfnetwork a df
```

Direction: When you call `net`, it says 'A rooted tree' which means its directed (a tree structure has a root and flows one way).

▼ Code

```
net
```

```
# A sfnetwork with 30 nodes and 29 edges
#
# CRS:  EPSG:3857
```

```
#
# A rooted tree with spatially explicit edges
#
# Edge data: 29 × 19 (active)
   from    to hyriv_id next_down main_riv length_km dist_dn_km dist_up_km
  <int> <int>    <int>     <int>    <int>     <dbl>      <dbl>      <dbl>
1     1     2 40746330  40746814 41067217     2.51       1469.       108.
2     2     3 40746814  40747465 41067217     1.23       1468        109.
3     4     5 40747463  40747949 41067217     0.410      1465.       112.
4     3     4 40747465  40747463 41067217     2.26       1466.       111.
5     5     6 40747949  40748974 41067217     1.08       1464.       113.
6     6     7 40748974  40749223 41067217     2.01       1462.       114.
# ℹ 23 more rows
# ℹ 11 more variables: catch_skm <dbl>, upland_skm <dbl>, endorheic <int>,
#   dis_av_cms <dbl>, ord_stra <int>, ord_clas <int>, ord_flow <int>,
#   hybas_l12 <dbl>, shape_length <dbl>, geometry <LINESTRING [m]>, weight [m]
#
# Node data: 30 × 1
           geometry
        <POINT [m]>
1 (9311180 3338311)
2 (9309324 3336725)
3 (9308397 3335667)
# ℹ 27 more rows
```

Define path

- Shortest path from node # (3) to # (15) using `weight` column
    - Would count edges [fewest segments] instead of distance if not `weight`
    - # = Node IDs (row number in nodes table)
- Returns: list of nodes that are the shortest path/route (EX: `[3, 7, 12, 15]` = path goes thru nodes 3→7→12→15)
- **Direction** (checking if it worked)
    - `paths_down` returns a valid path
    - `paths_up` is invalid and returns a warning!

```
# Define path: find shortest path from node 3 and 15 using weight column
paths_down = st_network_paths(net, from = 3, to = 15, weight = "weight")
```

```
# Define path: find shortest path from node 15 and 3 (UPSTREAM)
paths_up = st_network_paths(net, from = 15, to = 3, weight = "weight")
```

```
Warning in shortest_paths(x, from, to, weights = weights, output = "both", : At
vendor/cigraph/src/paths/dijkstra.c:534 : Couldn't reach some vertices.
```

List nodes and edges

```
# lists nodes
paths_down %>%
  slice(1) %>% # first row (first path found)
  pull(node_paths) %>% # extract Node_path (juctions/points you pass thru)
  unlist() # List -> vector
```

```
 [1]  3  4  5  6  7  8  9 10 11 12 13 14 15
```

```
# lists edges
paths_down %>%
  slice(1) %>%
  pull(edge_paths) %>% # extract edge_path (river segments)
  unlist()
```

```
 [1]  4  3  5  6  7  8  9 10 11 12 13 14
```

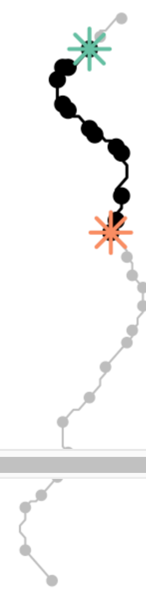
Plot

3 levels to the plotting:

1. Base layer: plot entire path `plot(net)`
2. Path: (*use function*)
3. Start and end node points

```
plot_path = function(node_path) { # input = vector of node IDs as table
  net %>%
    activate("nodes") %>% # Node table
    slice(node_path) %>% # Select nodes in the path
    plot(cex = 1.5, lwd = 1.5, add = TRUE) # plot thise nodes on top od existing plot
}


colors = sf.colors(3, categorical = TRUE) # 3 distcict colors for viz


# Plotting entire network in grey (base layer)
plot(net, col = "grey")

# Plot nodes
paths_down %>%
```

```
  pull(node_paths) %>% # extract Node_path (juctions/points you pass thru) of `paths`
  walk(plot_path) # applies `plot_path` function for each path

# Plot start and end nodes
net %>%
  activate("nodes") %>%
  st_as_sf() %>% # convert nodes to sf object for plotting
  slice(c(3, 15)) %>% # Get only nodes 3 and 15 (start and end)
  plot(col = colors, pch = 8, cex = 2, lwd = 2, add = TRUE) # Plot as stars, in color, on
```



Plotting Direction of River

Show flow direction: Each arrow points from line start → midpoint

```
# Plot base river
plot(st_geometry(trial_river), col = "grey") # Draws rivee network in grey

# Add arrows showing flow direction
midpoints <- trial_river %>%
  st_line_sample(sample = 0.5) %>%   # Extract midway point at each line
  st_cast("POINT") %>% # point geometery
  st_coordinates() %>% # Convert to x,y coorfinate matrix
```

```
  as.data.frame()

# Get start points for arrow direction
startpoints <- trial_river %>%
  st_cast("POINT") %>% # covert line -> points
  filter(row_number() %% 2 == 1) %>%  # first point of each line (`%% 2 == 1` filters for
  st_coordinates() %>% # x,y coordinates
  as.data.frame()
```

```
Warning in st_cast.sf(., "POINT"): repeating attributes for all sub-geometries
for which they may not be constant
```

```
# Draw arrows
arrows(startpoints$X, startpoints$Y, # From x and y
       midpoints$X, midpoints$Y,  # to x and y
       length = 0.1, col = "blue")
```