Day 4: Sensors

Before you start, update your branch to `post-lecture4` which includes all the code changes I made during the lecture today:

```
cd goby3-course
git fetch
git checkout post-lecture4
```

Assignment 1:

Goal: Finalize the sensor simulator and sensor driver to parse the CTD data.

Task:

In `goby3-course/homework/day4-sensors/ctd_data.csv` you will find an average profile from a cruise off Hawaii. We will use these data to feed our simulator.

Also, remember the interface definition for our "real" CTD:

```
RS-232, 9600 baud
> means message from the control computer to the CTD
< means message from the CTD to the control computer
*CS is the standard NMEA-0183 checksum

Wake up the CTD
> $ZCCMD,WAKE*CS\r\n
Wake received, CTD out of low power mode and ready to commence logging
< $ZCACK,WAKE*CS\r\n

Start logging
> $ZCCMD,START*CS\r\n
Logging started
< $ZCACK,START*CS\r\n

Data (streams at 1 Hz)
< $ZCDAT,<salinity>,<temp, deg C>,<depth, meters>*CS
< $ZCDAT,31.5,10.4,150*CS\r\n
< $ZCDAT,31.5,10.3,151*CS\r\n
< $ZCDAT,31.4,10.2,152*CS\r\n

Stop logging
> $ZCCMD,STOP*CS\r\n
Logging stopped
< $ZCACK,STOP*CS\r\n

Enter low power mode
> $ZCCMD,LOWPOWER*CS\r\n
< $ZCACK,LOWPOWER*CS\r\n
```

- Update the `goby3_course_ctd_simulator`:
    - to begin streaming data (`$ZCDAT`) at 1 Hz once a `$ZCCMD,START` message is received. Use the values in the .csv file for temperature and salinity and add a random pertubation to each value based on a normal distribution (`std::normal_distribution` in `#include <random>`):
        - pressure: read depth by subscribing to the `goby::middleware::frontseat::node_status` group (protobuf type: `goby::middleware::frontseat::protobuf::NodeStatus`). For the the purpose of this simulator you can assume depth (in meters) is equal to pressure (in dBars).
        - temperature: mean: 0, variance: 1 deg C
        - salinity: mean: 0, variance: 2
    - to stop streaming data when a `$ZCCMD,STOP` message is received.

- Update the `goby3_course_ctd_driver`:
    - to read and parse the `$ZCDAT` data into a new Protobuf message (e.g. CTDSample). Compute the empirical sound speed and add it to this message. Publish this message on a new group on the interprocess layer.

Assignment 2:

Goal: Publish the CTD data to the USV, where it will be aggregated and logged using the `goby_logger` application. Plot some of the logged data.

Task:

- Subscribe to the CTDSample message you published in Assignment 1 in `goby3_course_auv_manager`, and store the latest sample as a class variable. Update the `goby3_course::dccl::NavigationReport` message (`src/lib/messages/nav_dccl.proto`) to include sound speed in the message. When you publish `goby3_course::groups::auv_nav`, include the latest sample's sound speed within the NavigationReport message.
- Add `goby_logger` to the `usv.launch` for the Trail example (as well as to the `launch/trail/config/usv.pb.cfg.py` configuration generator along with a template file in `launch/trail/config/templates`). The configuration template you can use is:

```
# launch/trail/config/templates/goby_logger.pb.cfg.in
$app_block
$interprocess_block

log_dir: "$goby_logger_dir"
load_shared_library: "$goby3_course_messages_lib"
```

Wihtin `usv.pb.cfg.py` you can use `debug_log_file_dir` for `goby_logger_dir` which would put the log files in `goby3_course/logs/usv`.

Run the entire mission (`./all.launch`) and ensure you're logging data to `goby3_course/logs/usv/*.goby`. Once the USV has made a complete circuit around its waypoints, you can stop the mission and process the log data.

TODO: insert log processing instructions.

Wrap up

And that's the week! Thanks for joining us, and I hope you learned some useful tools.

Solutions (Toby)

My solutions are pushed to the `post-homework4` branch of goby3-course. Please reference the code together with this text.

Assignment 1:

First I added code to read the .csv file into a data structure. I stored the values in two maps so that I can use `goby::util::linear_interpolate`:

```
    // depth -> temperature
    std::map<quantity<si::length>, quantity<absolute<celsius::temperature>>> temperatures_;
    // depth -> salinity
    std::map<quantity<si::length>, double> salinities_;
```

Then, I changed the application type from `middleware::MultiThreadStandaloneApplication` to `zeromq::MultiThreadApplication`. At that point, I updated `auv.launch` and `auv.pb.cfg.py` to use a new template file `goby3_course_ctd_simulator.pb.cfg.in`.

Then, I subscribed to `goby::middleware::frontseat::node_status` for the vehicle depth data. I added a boolean for whether we are streaming data or not, and set to true when we get `$..CMD,START` and false after `$..CMD,STOP`.

I added loop() back in at 1 Hz, and used it to stream when we're streaming. Next I added the requested random variation to each sample.

I then created a CTDSample message in `src/lib/messages/ctd.proto` for use by the driver. I populated it with the data from `$..DAT` and published it (on interprocess) to a new group `ctd_sample`.

```
message CTDSample
{
    option (dccl.msg) = {
        unit_system: "si"
    };

    required uint32 time = 1 [(dccl.field).units = { base_dimensions: "T" }];
    required double salinity = 2;
    required double temperature = 3
        [(dccl.field).units = { base_dimensions: "K" system: "celsius" }];
    required double depth = 4 [(dccl.field).units = { base_dimensions: "L" }];
    required double soundspeed = 5
        [(dccl.field).units = { base_dimensions: "LT^-1" }];
}
```

Assignment 2:

I subscribed to `ctd_sample` in the `goby3_course_auv_manager`, and stored the latest sound speed to a class member variable:

```
    interprocess().subscribe<groups::ctd_sample>(
        [this](const goby3_course::protobuf::CTDSample& sample) {
            latest_soundspeed_ = sample.soundspeed_with_units();
        });
```

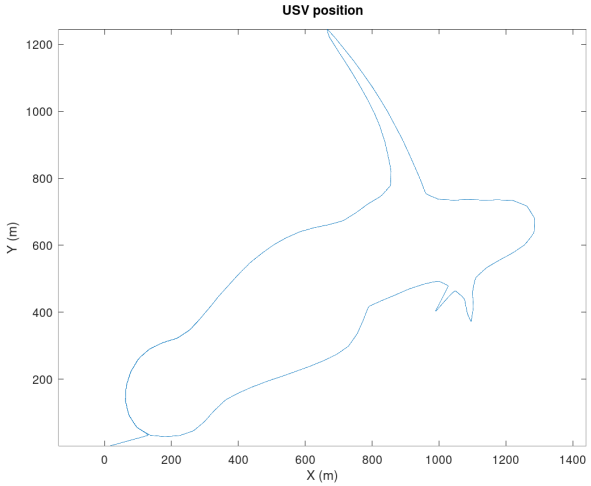
Then, I added the sound speed field to the NavigationReport:

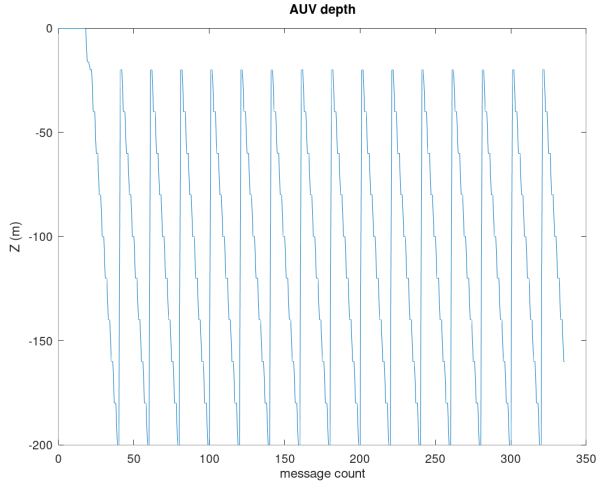
```
message NavigationReport
{
// ...
    optional double soundspeed = 9 [(.dccl.field) = {
        min: 1450
        max: 1550
        precision: 0
        units { derived_dimensions: "length/time" }
    }];
}
```

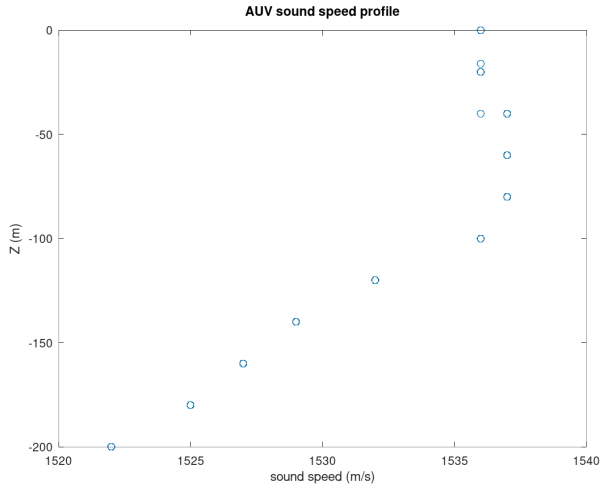
Now, I added the `goby_logger` as requested to the `usv.launch` and affiliated files. After running the mission I collected a 'usv*.goby' log file (usv_29930516T214924.goby). I converted the file to HDF5 and then plotted some figures as requested:

```
load ~/goby3-course/logs/usv/usv_29930516T214924.h5
close all;

% plot usv x/y
figure;
usv_nav = goby3_course__usv_nav_1.goby3_course_dccl_NavigationReport;
plot(usv_nav.x, usv_nav.y);
axis equal;

% plot auv depth
figure;
auv_nav = goby3_course__auv_nav_2.goby3_course_dccl_NavigationReport;
plot(auv_nav.z);

% plot ssp
figure;
plot(auv_nav.soundspeed, auv_nav.z, 'o');
```

The resulting figures are:


USV position
Y (m)
X (m)
1200
1000
800
600
400
200
0
200
400
600
800
1000
1200
1400


AUV depth
Z (m)
message count
0
-50
-100
-150
-200
0
50
100
150
200
250
300
350


AUV sound speed profile
Z (m)
sound speed (m/s)
0
-50
-100
-150
-200
1520
1525
1530
1535
1540