Tekkotsu Behaviors & Events

15-494 Cognitive Robotics
David S. Touretzky &
Ethan Tira-Thompson

Carnegie Mellon
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Behaviors

- Behaviors are *classes* defined in .h files
  - Add them to the ControllergGUI “Mode Switch” menu by calling `addItem` in `StartupBehavior_SetupModeSwitch.cc`
  - Double click on the “Mode Switch” menu item to instantiate
  - Instantiated by `BehaviorSwitchControl()` when requested by the ControllerGUI
  - When you stop a behavior (double click on the menu item), the instance is deleted

Five Behavior Components

```
#include “Behaviors/BehaviorBase.h”

class PoodleBehavior : public BehaviorBase {
```

- Constructor

```
  PoodleBehavior() : BehaviorBase(“PoodleBehavior”) {}
```

- DoStart() activates the behavior

```
  virtual void DoStart() {
    BehaviorBase::DoStart();
    cout << getName() << “ is starting up.” << endl;
  }
```

Five Behavior Components

- DoStop() deactivates the behavior

```
virtual void DoStop() {
   cout << getName() << " is shutting down." << endl;
   BehaviorBase::DoStop();
 }
```

- processEvent processes requested event types

```
virtual void processEvent(const EventBase &event) {
   cout << getName() << " got event: "
        << event.getDescription() << endl;
 }
```

Five Behavior Components

- getClassDescription() returns a string displayed by ControllerGUI pop-up help

```
    virtual std::string getClassDescription() {
      return “Demonstration of a simple behavior”;
    }


};  // end of PoodleBehavior class definition
```

Behaviors are Coroutines

- Behaviors are coroutines, not threads:
  - Many can be “active” at once, but...
  - Only one is actually running at a time.
  - No worries about mutual exclusion.
  - Must voluntarily relinquish control so that other active behaviors can run.
- BehaviorBase is a subclass of:
  - EventListener
  - ReferenceCounter
- Behaviors will be deleted if they are deactivated and the reference count goes to zero.

Tekkotsu Releases

- Tekkotsu.org holds the current stable release and accompanying documentation.
- tekkotsu.no-ip.org holds the latest (bleeding edge) version of Tekkotsu, and the latest version of the documentation.
- This class will be using bleeding edge software.
- The “Reference” link on the course home page points to the bleeding edge documentation.

Browsing the Documentation

- “Class List” in left nav bar
  - Click on class name (`BehaviorBase`) to see documentation page
  - Click on method name (`DoStart`) to jump to detailed description
  - Click on line number to go to source code

- “Directories” in left nav bar shows major components
  - Look at the `Behaviors` and `Events` directories

Searching the Source

- Use the search box in the documentation pages to search for any identifier.
  - Example: `NearIRDistOffset`

- Use the “ss” shell script to grep the source code:

```
> cd ~/Tekkotsu

> ss NearIR
```

Events

- Events are subclasses of `EventBase`
- Three essential components:
  1. Generator ID: what kind of event is this?

     buttonEGID, visionEGID, timerEGID, ...

  2. Source ID: which sensor/actuator/behavior/thing generated it?

     RobotInfo::HeadButOffset

  3. Type ID, which must be one of:

     activateETID
     statusETID
     deactivateETID

Where are these Defined?

- EventGeneratorID_t defined in EventBase.h
- EventTypeID_t defined in EventBase.h

```
enum EventTypeID_t {
    activateETID,
    statusETID,
    deactivateETID,
    numETIDs
};
```

- Event source ids are specific to the event type:
  - HeadButOffset defined in ERS7Info.h
  - visPinkBallSID defined in ProjectInterface.h

Subscribing to Events

addListener(*listener*,*generator*,*source*,*type*)

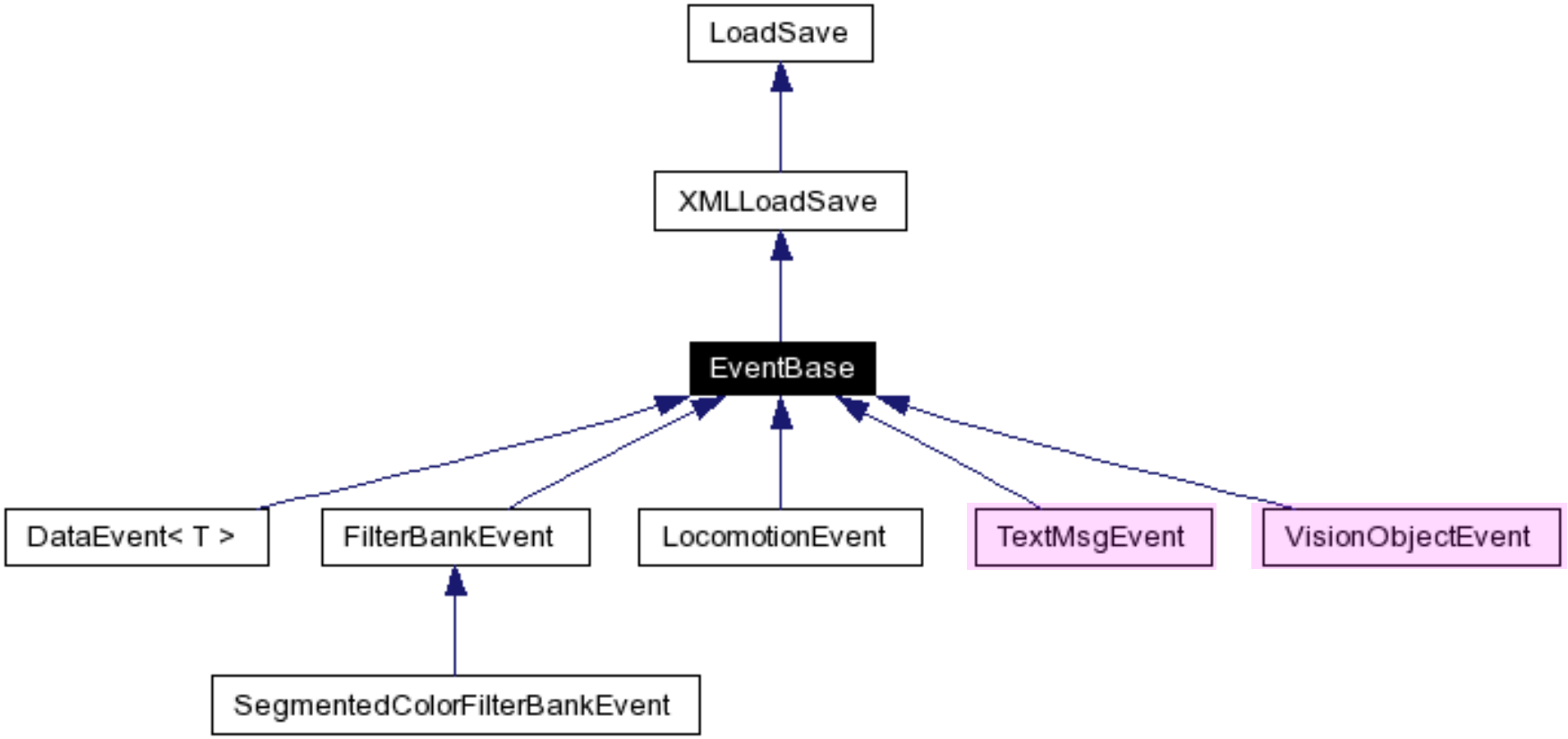
```
#include “EventRouter.h”

virtual void DoStart() {
  BehaviorBase::DoStart();
  erouter->addListener(this,
                       EventBase::buttonEGID,
                       RobotInfo::LFrPawOffset,
                       EventBase::activateETID);
}
```

Processing Events

```
virtual void processEvent(const EventBase &event) {
  switch ( event.getGeneratorID() ) {

    case EventBase::buttonEGID:
      cout << “Button press: “ << event.getDescription()
           << endl;
      break;

    default:
      cout << “Unexpected event: “
           << event.getDescription() << endl;
  }
}
```

Types of Events

- What are some subclasses of EventBase?

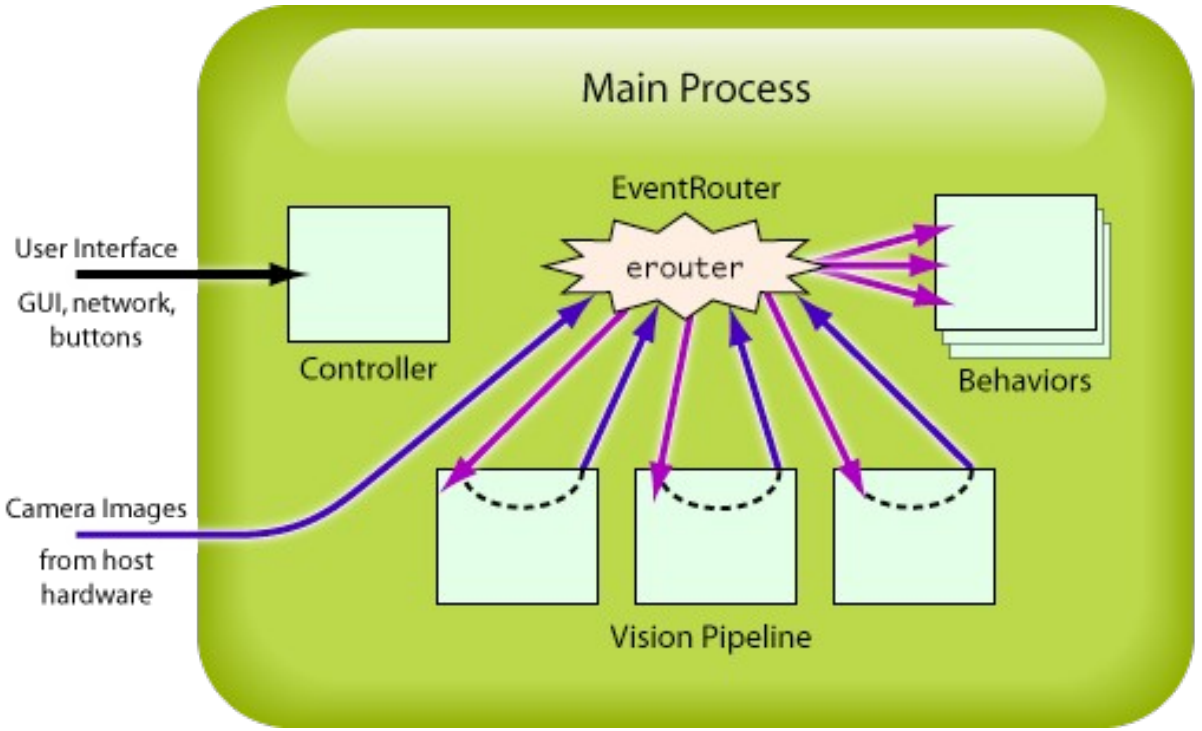


Vision Object Events

- VisionObjectEvent is a subclass of EventBase
- The vision pipeline includes an “object detector” that looks for pink blobs, like the AIBO's ball.
- The center and area of the largest blob are reported by posting a VisionObjectEvent (if anyone's listening.)
  - visObjEGID
  - visPinkBallSID
  - activate, status, deactivate ETIDs

The Event Router

- Runs in the Main process.
- Distributes events to the Behaviors listening for them.



Subscribing to Vision Events

```
#include “Events/VisionObjectEvent.h”
#include “Shared/ProjectInterface.h”


virtual void DoStart() {
  BehaviorBase::DoStart();
  erouter->addListener(this,
                       EventBase::visObjEGID,
                      ProjectInterface::visPinkBallSID);
}
```

Casting VisionObject Events

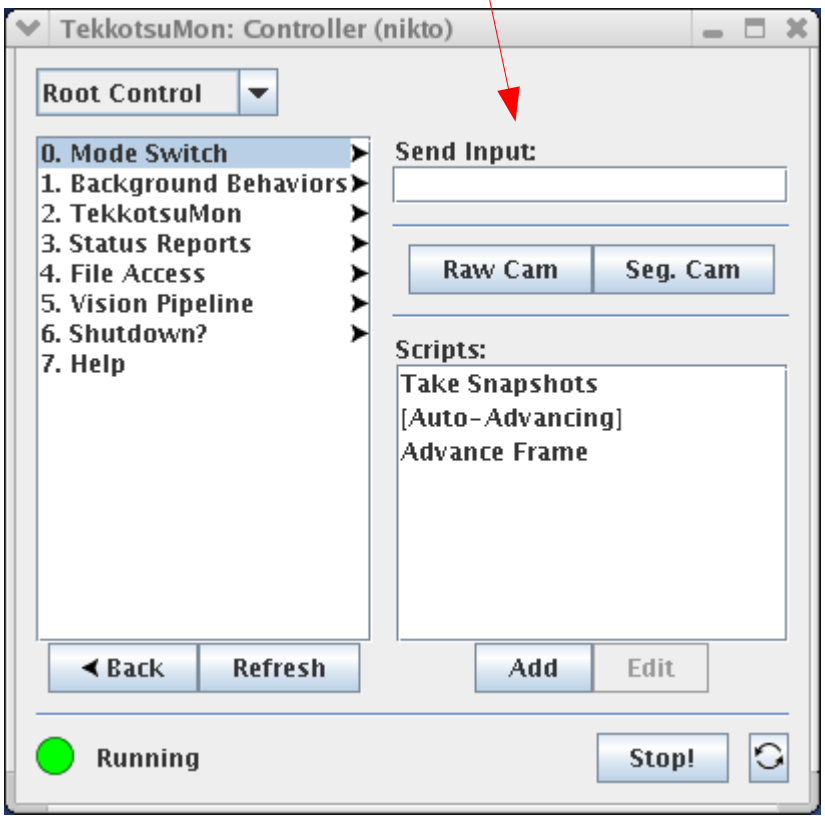
```
void processEvent(const EventBase &event) {
  switch ( event.getGeneratorID() ) {

  case EventBase::visObjEGID: {
    const VisionObjectEvent &visev =
      dynamic_cast<const VisionObjectEvent&>(event);
    if ( visev.getTypeID() == EventBase::activateETID ||
         visev.getTypeID() == EventBase::statusETID)
      cout << “Saw pink ball at (“
           << visev.getCenterX() << “, “
           << visev.getCenterY() << “)” << endl;
    else  // deactivate event
      cout << “Lost sight of the ball!” << endl;
    };
    break;

  case EventBase::buttonEGID:
    ...
```

Text Message Events

You can send text messages to the AIBO via the ControllerGUI's "Send Input" window:

```
!msg Hi there
```

This causes the behavior controller to post a textmsgEvent.



Subscribing to TextMsg Events

```
#include “Events/TextMsgEvent.h”

virtual void DoStart() {
  BehaviorBase::DoStart();
  erouter->addListener(this, EventBase::textmsgEGID);
}
```

The source ID is meaningless (it's -1).

The type ID is always statusETID.

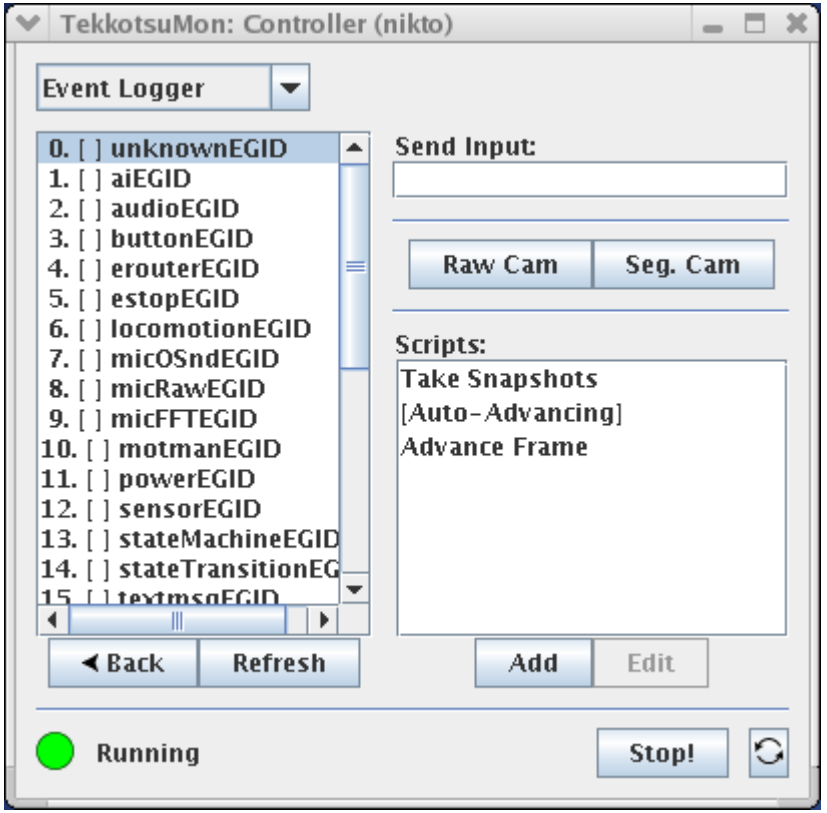
Casting TextMsg Events

```
void processEvent(const EventBase &event) {
  switch ( event.getGeneratorID() ) {

  case EventBase::textmsgEGID: {
    const TextMsgEvent &txtev =
      dynamic_cast<const TextMsgEvent&>(event);
    cout << “I heard: '” << txtev.getText() << “'” << endl;
    };
    break;

  case EventBase::buttonEGID:
    ...
```

The Event Logger

- Root Control
  > Status Reports
  > Event Logger

- Outputs to console: telnet to port 59000 to see the log



Timers

Timers are good for two kinds of things:

- Repetitive actions: “Bark every 30 seconds.”
  - Whenever a timer expires and a timer expiration event is posted, the timer should be automatically restarted.
- Timeouts: “If you haven't seen the ball for 5 seconds, bark and turn around.”
  - One-shot timer. Will need to be cancelled if we see the ball before the time expires.

addTimer

- addTimer(*listener*, *source*, *duration*, *repeat*)
  - listener is normally this
  - source is an arbitrary integer
  - duration is in milliseconds
  - repeat should be “true” if a sequence of timer events is desired
- Starts timer and automatically listens for the event.
- Timers are specific to a behavior instance; can use the same source id in other behaviors without interference.
- Behaviors can receive another's timer events if they use addListener to explicitly listen for them.
- removeTimer(*listener*, *source*)

Timer Example

```
#include “Behaviors/BehaviorBase.h”
#include “EventRouter.h”

virtual void DoStart() {
  BehaviorBase::DoStart();

  erouter->addListener(this,
                       EventBase::buttonEGID,
                       RobotInfo::LFrPawOffset,
                       EventBase::activateETID);

  erouter->addListener(this,
                       EventBase::buttonEGID,
                       RobotInfo::RFrPawOffset,
                       EventBase::activateETID);
}
```

Timer Example

```
virtual void processEvent(const EventBase &even) {
  switch ( event.getGeneratorID() ) {

  case EventBase::buttonEGID:
    if ( event.getSourceID() == RobotInfo::LFrPawOffset )
      erouter->addTimer(this, 1234, 5000, false);
    else if ( event.getSourceID() == RobotInfo::RFrPawOffset )
      erouter->removeTimer(this, 1234);
  break;

  case EventBase::timerEGID:
    cout << “Timer expired!” << endl;
  }

}
```

What does this behavior do?

The Tekkotsu Simulator

- Really useful for debugging vision code, but...

```
> cd ~/project
```
(or whatever your project name is)

```
> make sim
> ./tekkotsu-ERS7
```

- In another terminal tab:

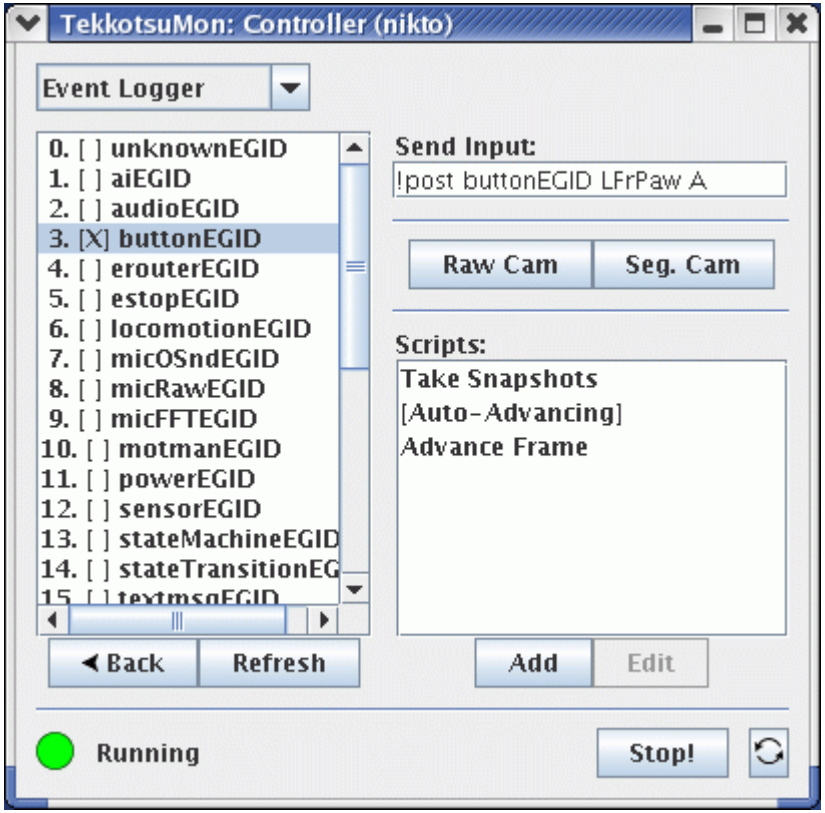
```
> ControllerGUI localhost
```

ControllerGUI Can Post Events to the Simulator

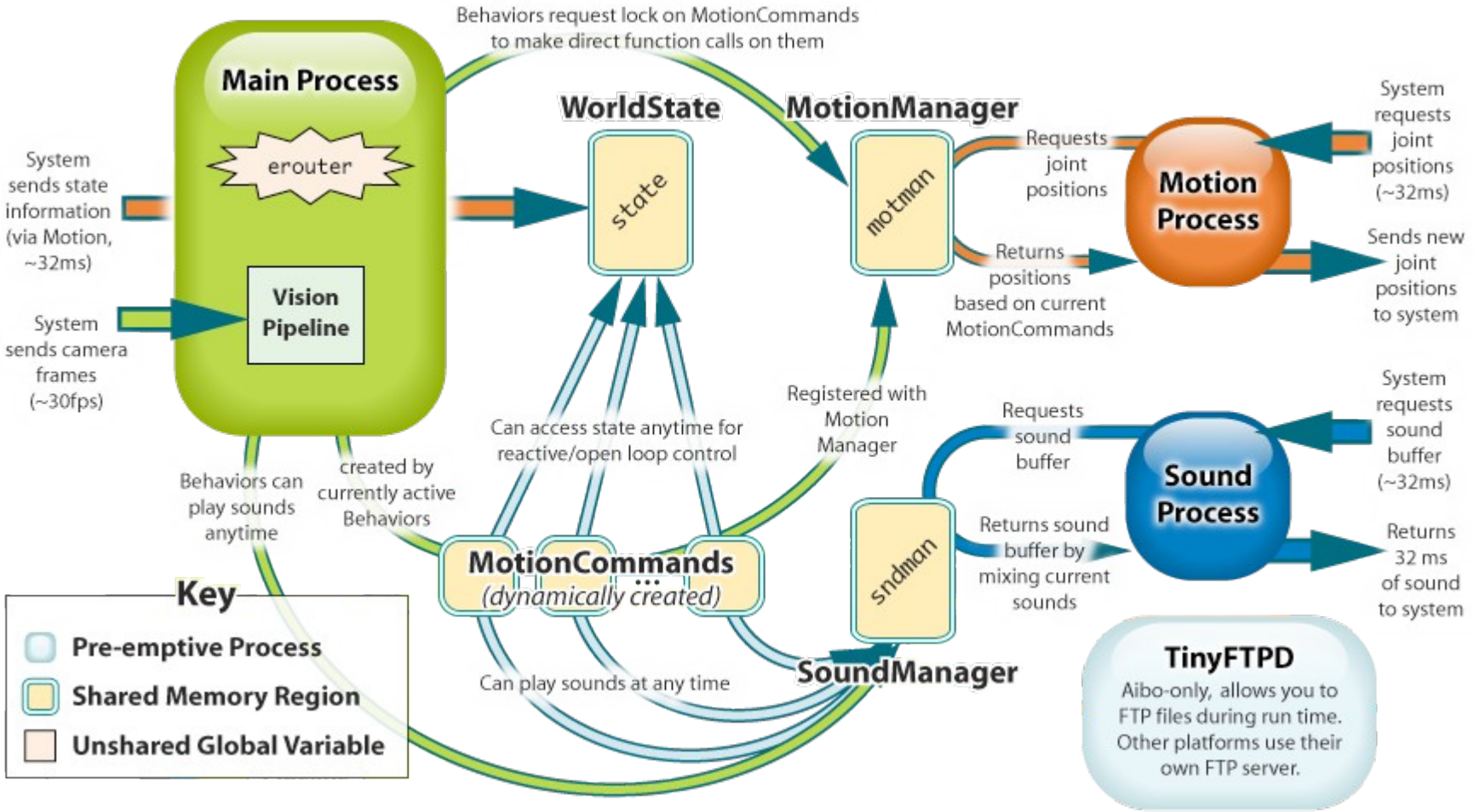
- Type this command in the “Send Input” box:

```
!post buttonEGID LFrPaw A
```

- Monitor the result using the Event Logger



Tekkotsu Architecture: Main



World State

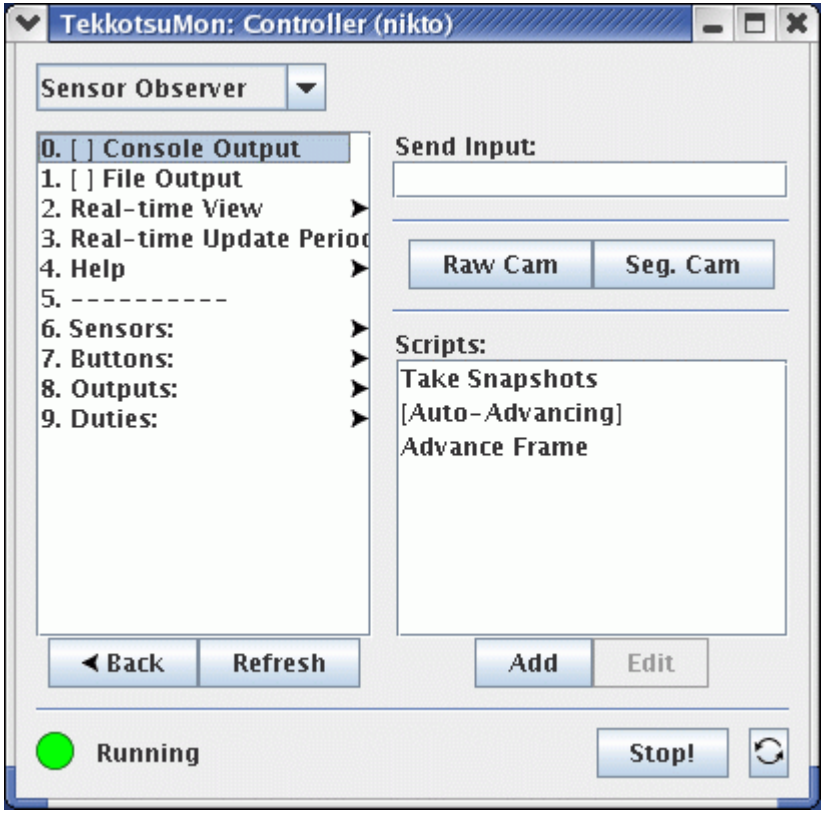
- Shared memory structure between Main and Motion
- Updated every 32 msec
- sensorEGID events announce each update
- Contents:
  - joint positions, duty cycles, and PID settings
  - button states: `state->buttons[LFrPawOffset]`
  - IR range readings: `state->sensors[NearIRDistOffset]`
  - accelerometer readings
  - battery state, thermal sensor
  - commanded walking velocity (x,y,a)

Sensor Observer

- Root Control
  > Status Reports
  > Sensor Observer

- Try monitoring the accelerometers.

- Then pick up the robot and wave it around.



Control of Effectors

- How do we make the robot move?
- Must send commands to each device (head, leg, and tail joints, ear servos, LED display, etc.) every 32 ms.
- This is real-time programming.
- Can't spend too long computing command values!
- Best to do all this in another process, independent of user-written behaviors, so motion can be smooth.

Tekkotsu Architecture: Motion