

Advanced State Machine Programming

15-494 Cognitive Robotics
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Three Mechanisms for Communication Among States

- 1) SignalTrans allows one state to send a message to another as part of a transition, e.g., to send an int:

```
state1 =S<int>=> state2
```

- 2) Variables defined in a parent state can be accessed by children using \$provide and \$reference.
- 3) Sketch and shape spaces are shared across all states, so sketches/shapes created by one state can be accessed by another using GET_SKETCH and GET_SHAPE.

1) State Signaling

Two principal uses:

- Transmit an arbitrary value, e.g., a float or struct
- Implement an n-way branch. In this case the signal is an enumerated type.

Both are implemented by posting a `DataEvent<T>` and using a `SignalTrans<T>` to test for the event.

Shorthand notation: `=S<T>=>` or `=S<T>(v)=>`

Transmit an Arbitrary Signal

```
$nodeclass TransmitDemo : StateNode {  
  
    $nodeclass Pitcher : StateNode : doStart {  
        float x = ...; // some arbitrary computation  
        postStateSignal<float>(x);  
    }  
  
    $nodeclass Catcher : StateNode : doStart {  
        float val = extractSignal<float>(event);  
        cout << "Message received: " << val << endl;  
    }  
  
    $setupmachine{  
        startnode: Pitcher =S<float>=> Catcher  
    }  
  
}
```

The variable event is automatically defined for you and bound to the event that caused the transition into this state. The `extractSignal` call will return a default float value (0.0f) if event is not an instance of `DataEvent<float>`.

N-Way Branch

```
$nodeclass ChooseDemo : StateNode {
  enum choice {goLeft, goRight, goStraight};

  $nodeclass Chooser : StateNode : doStart {
    float x = rand()/(1.0f + RAND_MAX);
    if ( x < 0.1 ) postStateSignal<choice>(goLeft);
    else if ( x < 0.2 ) postStateSignal<choice>(goRight);
    else postStateSignal<choice>(goStraight);

  $setupmachine{
    startnode: Chooser
    startnode =S<choice>(goLeft)=> Turn(M_PI/2)
    startnode =S<choice>(goRight)=> Turn(-M_PI/2)
    startnode =S<choice>(goStraight)=> WalkForward(100)
  }
}
```

2) Parent-Defined Variables

```
$nodeclass SharedVarDemo : StateNode {
    $provide int counter;

    $nodeclass BumpIt : StateNode : doStart {
        $reference SharedVarDemo::counter;
        ++counter;
    }

    $nodeclass Report : StateNode : doStart {
        $reference SharedVarDemo::counter;
        cout << "Counter = " << counter << endl;
    }

    virtual void doStart {
        counter = 0; // can't rely on constructor if called twice
    }

    $setupmachine{
        startnode: BumpIt =N=> BumpIt =N=> BumpIt =N=> Report
    }
}
```

More State Signaling

- `postStateCompletion()`
 - Use the `=C=>` transition
 - Indicates normal completion of the state's action.
- `postStateFailure()`, `postStateSuccess()`
 - Use `=F=>` for abnormal completion, e.g., search failed.
 - Use `=S=>` for a third outcome if `=C=>` already used
- `postParentCompletion()`, `postParentFailure()`
 - Can be used to trigger a transition out of the parent node.
 - This is how nested state machines can “return” to the parent state machine.

Nested State Machine (1)

```
$nodeclass LookForIt : VisualRoutinesStateNode {  
  $nodeclass TakeImage : MapBuilderNode : doStart {  
    mapreq->addObjectColor(ellipseDataType,"green");  
  }  
  
  $nodeclass CheckResult : VisualRoutineStateNode : doStart {  
    if ( camShS.allShapes.size() > 0 )  
      postStateSuccess();  
    else  
      postStateFailure();  
  }  
  
  $setupmachine{  
    startnode: TakeImage =C=> check  
  
    check: Checkresult  
    check =F=> startnode  
    check =S=> PostMachineCompletion  
  
  }  
}
```


Nested State Machine (2)

```
$nodeclass Trample : VisualRoutinesStateNode {
  $nodeclass GoToIt :
    PilotNode(PilotTypes::goToShape) : doStart {
      NEW_SHAPEVEC(ellipses, EllipseData,
                  select_type<EllipseData>(camShS));
      if ( ellipses.size() > 0 &&
          ellipses[0]->getSemiMajor() > 10 )
        pilotreq.targetShape = ellipses[0];
      else
        cancelThisRequest();
    }
}

$setupmachine{
  startnode: FindIt =C=> goto

  goto: GoToIt
  goto =F=> startnode
  goto =C=> SpeechNode("Trampled!")
}
}
```

When You Must Use =C=>

Completions are important when motion is involved:

```
straight: HeadPointerNode[getMC()->setJoints(0,0,0)]  
  =RND=> {left, right}
```

```
left: HeadPointerNode[getMC()->setJoints(0,0.5,0)]  
  =T(5000)=> straight
```

```
right: HeadPointerNode[getMC()->setJoints(0,-0.5,0)]  
  =T(5000)=> straight
```

What's the problem? The =RND=> transition won't wait for the head motion to complete. Same for =T(...)=> transition. Can only use =C=> here.

3) Accessing Sketches, Shapes

```
$nodeclass State1 : VisualRoutinesStateNode : doStart {  
  NEW_SHAPE(myline, LineData,  
            new LineData(camShS,  
                          Point(50,50),  
                          Point(100,200)));  
}
```

Variable myline goes out of scope upon exiting state1::doStart, but the shape it points to persists in camShS.

```
$nodeclass State2 : VisualRoutinesStateNode : doStart {  
  GET_SHAPE(myline, LineData, camShS);  
  if ( myline.isValid() )  
    myline->setColor("blue");  
}
```

GET_SHAPE retrieves the shape from camShS and binds a new local variable with that name so we can access it.