IMGD 1001:
Programming Practices; Artificial Intelligence

by

Mark Claypool (claypool@cs.wpi.edu)

Robert W. Lindeman (gogo@wpi.edu)

Outline

- Common Practices
- Artificial Intelligence

Common Practices: Version Control

- Database containing files and past history of them
- Central location for all code
- Allows team to work on related files without overwriting each other's work
- History preserved to track down errors
- Branching and merging for platform specific parts

Common Practices: Quality (1 of 3)

- *Code reviews* – walk through code by other programmer(s)
  - Formal or informal
  - "Two pairs of eyes are better than one."
  - Value is that the programmer is aware that others will read
- *Asserts*
  - Force program to crash to help debugging
    - Ex: Check condition is true at top of code, say pointer not NULL before continuing
  - Removed during release

Common Practices: Quality (2 of 3)

- Unit tests
  - Low level test of part of game
    - See if physics computations correct
  - Tough to wait until very end and see if there's a bug
  - Often automated, computer runs through combinations
  - Verify before assembling
- Acceptance tests
  - Verify high-level functionality working correctly
    - See if levels load correctly
- Note, above are programming tests (i.e., code, technical)
  - Still turned over to testers that track bugs, do gameplay testing

Common Practices: Quality (3 of 3)

- Bug database
  - Document & track bugs
  - Can be from programmers, publishers, customers
  - Classify by severity and priority
  - Keeps bugs from falling through cracks
  - Helps see how game is progressing

Common Practices: Pair (or "Peer") Programming

- Two programmers at one workstation
- One codes and tests, other thinks
  - Switch after fixed time
- Results
  - Higher-quality code
    - More bugs found as they happen
  - More enjoyable, higher morale
  - Team cohesion
  - Collective ownership

http://en.wikipedia.org/wiki/Pair_programming

Group Exercise

- Consider game where hero is in a pyramid full of mummies. Mummy – wanders around maze. When hero gets close, can "sense" and moves quicker. When it can see hero, rushes to attack. If wounded, flees.
- What "states" can you see? What are the transitions? Can you suggest Game Maker appropriate code?

Outline

- Common Practices (done)
- Artificial Intelligence (next)

Introduction to AI

- Opponents that are challenging, or allies that are helpful
  - Unit that is credited with acting on own
- Human-level intelligence too hard
  - But under narrow circumstances can do pretty well
  - Ex: chess and Deep Blue
- Artificial Intelligence
  - Around in CS for some time

Based on Chapter 5.3, *Introduction to Game Development*

AI for CS different than AI for Games

- Must be smart, but purposely flawed
  - Lose in a fun, challenging way
- No unintended weaknesses
  - No "golden path" to defeat
  - Must not look dumb
- Must perform in real time (CPU)
- Configurable by designers
  - Not hard coded by programmer
- "Amount" and type of AI for game can vary
  - RTS needs global strategy, FPS needs modeling of individual units at "footstep" level
  - RTS most demanding: 3 full-time AI programmers
  - Puzzle, street fighting: 1 part-time AI programmer

Based on Chapter 5.3, *Introduction to Game Development*

AI for Games: Mini Outline

- Introduction (done)
- Agents (next)
- Finite State Machines

Game Agents (1 of 3)

- Most AI focuses around game agent
  - Think of agent as NPC, enemy, ally or neutral
- Loops through: sense-think-act cycle
  - Acting is event specific, so talk about sense+think

Based on Chapter 5.3, *Introduction to Game Development*

Game Agents (2 of 3)

- *Sensing*
  - Gather current world state: barriers, opponents, objects
  - Need limitations: avoid "cheat" of looking at game data
  - Typically, same constraints as player (vision, hearing range)
    - Often done simply by distance direction (not computed as per actual vision)
  - Model communication (data to other agents) and reaction times (can build in delay)

Game Agents (3 of 3)

- *Thinking*
  - Evaluate information and make a decision
  - As simple or elaborate as required
  - Two ways:
    - Pre-coded expert knowledge, typically hand-crafted if-then rules + randomness to make unpredictable
    - Search algorithm for best (optimal) solution

Game Agents: Thinking (1 of 3)

- Expert Knowledge
  - Finite state machines, decision trees, … (FSM most popular, details next)
  - Appealing since simple, natural, embodies common sense
    - Ex: if you see enemy weaker than you, attack. If you see enemy stronger, then flee!
  - Often quite adequate for many AI tasks
  - Trouble is, often does not scale
    - Complex situations have many factors
    - Add more rules
    - Becomes brittle

Game Agents: Thinking (2 of 3)

- Search
  - Look ahead and see what move to do next
  - Ex: piece on game board, pathfinding (ch 5.4)
- Machine learning
  - Evaluate past actions, use for future
  - Techniques show promise, but typically too slow
  - Need to learn and remember

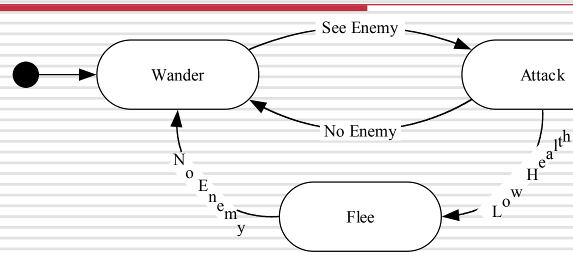
Game Agents: Thinking (3 of 3)

- Making agents stupid
  - Many cases, easy to make agents dominate
    - Ex: bot always gets head-shot
  - Dumb down by giving "human" conditions, longer reaction times, make unnecessarily vulnerable
- Agent cheating
  - Ideally, don't have unfair advantage (such as more attributes or more knowledge)
  - But sometimes might, to make a challenge
    - Remember, that's the goal, AI lose in challenging way
  - Best to let player know how agent is doing

AI for Games: Mini Outline

- Introduction (done)
- Agents (done)
- Finite State Machines (next)

Finite State Machines (1 of 2)



- Abstract model of computation
- Formally:
  - Set of states
  - A starting state
  - An input vocabulary
  - A transition function that maps inputs and the current state to a next state

Based on Chapter 5.3, *Introduction to Game Development*

Finite State Machines (2 of 2)

- Most common game AI software pattern
  - Natural correspondence between states and behaviors
  - Easy to understand
  - Easy to diagram
  - Easy to program
  - Easy to debug
  - Completely general to any problem
- Problems
  - Explosion of states
  - Often created with ad-hoc structure

Finite-State Machines: Approaches

- Three approaches
  - Hardcoded (switch statement)
  - Scripted
  - Hybrid Approach

Finite-State Machine: Hardcoded FSM

```
void RunLogic( int * state ) {
    switch( state )  {
        case 0:  //Wander
            Wander();
            if( SeeEnemy() )    { *state = 1; }
            break;

        case 1:  //Attack
            Attack();
            if( LowOnHealth() ) { *state = 2; }
            if( NoEnemy() )     { *state = 0; }
            break;

        case 2:  //Flee
            Flee();
            if( NoEnemy() )     { *state = 0; }
            break;
    }
}
```


Finite-State Machine: Problems with Switch FSM

1. Code is ad hoc
   - Language doesn't enforce structure
2. Transitions result from polling
   - Inefficient – event-driven sometimes better
3. Can't determine 1st time state is entered
4. Can't be edited or specified by game designers or players

Finite-State Machine: Scripted with alternative language

```
AgentFSM
{
    State( STATE_Wander )
        OnUpdate
            Execute( Wander )
            if( SeeEnemy )     SetState( STATE_Attack )
        OnEvent( AttackedByEnemy )
            SetState( Attack )
    State( STATE_Attack )
        OnEnter
            Execute( PrepareWeapon )
        OnUpdate
            Execute( Attack )
            if( LowOnHealth ) SetState( STATE_Flee )
            if( NoEnemy )     SetState( STATE_Wander )
        OnExit
            Execute( StoreWeapon )
    State( STATE_Flee )
        OnUpdate
            Execute( Flee )
            if( NoEnemy )     SetState( STATE_Wander )
}
```


Based on Chapter 5.3, *Introduction to Game Development*

Finite-State Machine: Scripting Advantages

1. Structure enforced
2. Events can be triggered, as well as polling
3. OnEnter and OnExit concept exists
4. Can be authored by game designers
   - Easier learning curve than straight C/C++

Finite-State Machine: Scripting Disadvantages

- Not trivial to implement
- Several months of development
  - Custom compiler
    - With good compile-time error feedback
  - Bytecode interpreter
    - With good debugging hooks and support
- Scripting languages often disliked by users
  - Can never approach polish and robustness of commercial compilers/debuggers
  - Though, some are getting close!

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Based on Chapter 5.3, *Introduction to Game Development*

Finite-State Machine: Hybrid Approach

- Use a class and C-style macros to approximate a scripting language
- Allows FSM to be written completely in C++ leveraging existing compiler/debugger
- Capture important features/extensions
  - OnEnter, OnExit
  - Timers
  - Handle events
  - Consistent regulated structure
  - Ability to log history
  - Modular, flexible, stack-based
  - Multiple FSMs, Concurrent FSMs
- Can't be edited by designers or players
- Kent says: "Hybrid approaches are evil!"

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Based on Chapter 5.3, *Introduction to Game Development*