IMGD 1001:
Debugging

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Debugging Introduction (1 of 2)

- Debugging is methodical process for removing mistakes in a program
- So important, whole set of tools to help. Called "debuggers"
  - Trace code, print values, profile
  - Integrated Development Environments (IDEs) (such as Game Maker) have one built in
- A good debugger is really useful...

Debugging Introduction (2 of 2)

- But debugging still frustrating
  - Beginners don't know how to proceed
  - Even advanced can get "stuck"
- Don't know how long it takes to find
  - Variance can be high
  - But can treat them in aggregate for predictions
- What are some tips?
- What methods can be applied?

Outline

- Five-step debugging process
- Prevention
- Game Maker specifics
- Debugging tips

Similar steps to Scientific Method

- Evaluation
- Conjecture
- Deduction
- Test

- Lather, rinse, repeat

- Let's do one

The Problem: Bubble Sort

- We need a routine to sort a list
- Algorithm:
  - Compare adjacent entries in the list
  - If they're out of order, swap them
  - Move on to the next pair
  - Repeat until the list is sorted
- Yes, this is vague
  - But you might be lucky to get this much description of an algorithm in your code!

Work Through …

```
def bubbleSort(L):
    for i in range(1, len(L) - 1):
        if L[i] >= L[i+1]:
            swap(L, i, i+1)
```

- Consider array:
  3 5 1 2
- Evaluate, then Conjecture/Deduction, then Fix, then Test

Step 1: Reproduce the Problem Consistently

- Find case where always occurs
  - Things like this: "Sometimes game crashes after kill boss" don't help much
- Identify steps to get to bug
  - Ex: start single player, room 2, jump to top platform, attack left, …
  - Produces systematic way to reproduce
- Consider record/playback
  - Console developers use camcorder!

Step 2: Collect Clues

- Collect clues as to where is bug
  - Clues suggest where problem might be
  - Ex: if crash using projectile, what about that code that handles projectile creation and shooting?
- And beware that some clues are false
  - Ex: if bug follows explosion, may think they are related, but may be from something else
- Don't spend too long - get in and observe
  - Ex: crash when shooting arrow. See reference pointer from arrow to unit that shot arrow should get experience points, but it is NULL
  - That's the bug, but *why* is it NULL?

Step 3: Pinpoint Error

1) Propose a hypothesis and prove or disprove
   - Ex: suppose arrow pointer corrupted during flight.
   - Add code to print out values of arrow in air.
   - But equals same value that crashes.

   → *Hypothesis is wrong*. But now have new clue!
   - Ex: suppose unit deleted before experience points added. Print out values of all units before fire and after all deleted.

   → *Yep, that's it!*
2) Binary-search method (note, can use in conjunction with hypothesis test above, too)
   - Sherlock Holmes: "when you have eliminated the impossible, whatever remains, however improbably, must be the truth."
   - Setting breakpoints, look at all values, until discover bug
   - The "divide" part means break it into smaller sections
     - Ex: if crash, put breakpoint ½ way. Is it before or after? Repeat.
   - Look for anomalies, NULL or NaN values

Step 4: Repair the Problem

- Propose solution. Exact solution depends upon stage of problem.
  - Ex: late in code cannot change data structures. Too many other parts use it!
  - Worry about "ripple" effects.
- Ideally, want original coder to fix.
  - If not possible, at least try to talk with original coder for insights.
- Consider other similar cases, even if not yet reported
  - Ex: other projectiles may cause same problem as arrows did

Step 5: Test Solution

- Obvious, but can be overlooked if programmer is "sure" they have fix
  - Programmer can be wrong!
- So, test that the solution repairs bug
  - Best done by independent tester
- Test if other bugs introduced
  - Beware of "ripple" effect

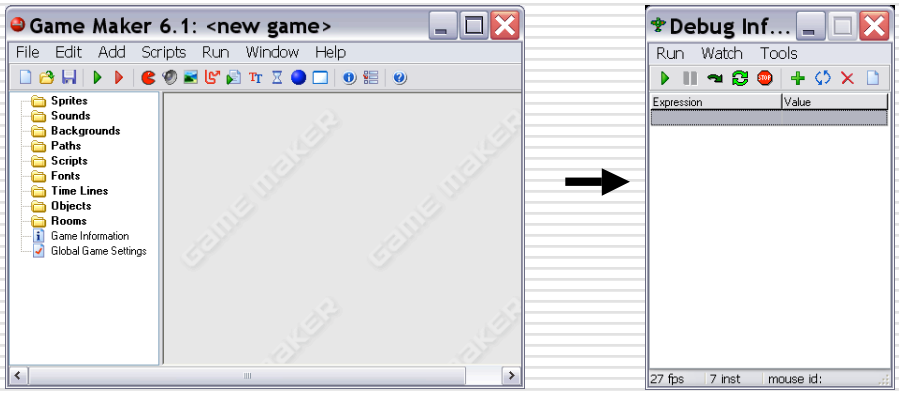
Debugging Prevention

- Use consistent style, variable names
- Indent code, use comments
- Always initialize variables when declared
- Avoid hard-coded constants
  - They make code brittle
- Add infrastructure, tools to assist
  - Alter game variables on fly (speed up)
  - Visual diagnostics (maybe on avatars)
  - Log data (events, units, code, time stamps)
- Avoid identical code
  - Harder to fix if bug found
  - Use a script/function
- Verify coverage (test all code) when testing

Game Maker: Print Messages

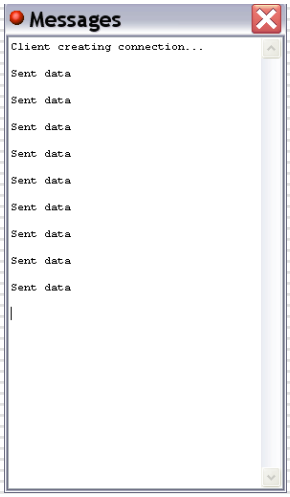
- Display a Message
  - object → main2 → info
- Or, in code
  - show_message('Executed this code')
  - show_message('num:' + string(number_here))
- Beware if done every step!
  - Save code ahead of time

Game Maker: Debug Mode



Game Maker: Print Debug Messages

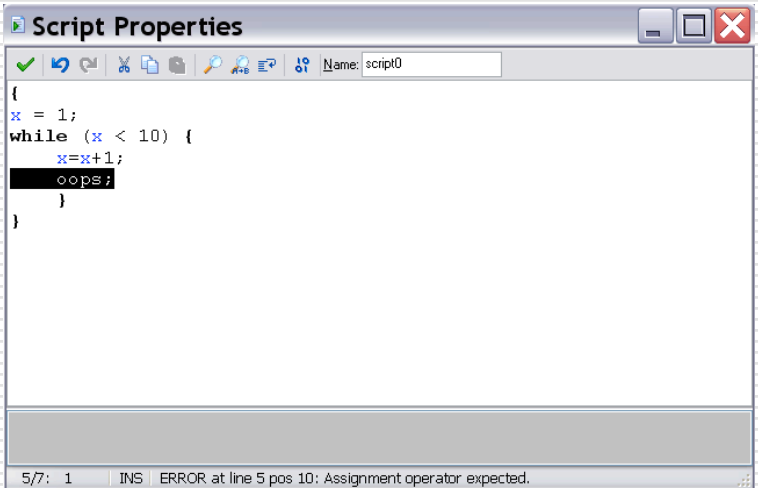
- Like show_message but in debug mode only
  - Note, doesn't pause
- In code
  - show_debug_message ('Executed this code')
- Need to run in debug mode
- Debug Information
  - → Tools
  - → Show Messages



Game Maker: Log Messages

- Write messages to file
- Example:
  - At beginning (maybe create log object)
    - global.log_name = "logfile";
      global.fid = file_text_open_write(global.log_name);
  - Then, where needed:
    - file_text_write_string(global.fid, "Debug message here") ;
  - Close when done (object → event other → game end):
    - file_text_close(global.fid)
- Note: files also useful for save/load game, etc.

Game Maker: Script/Code Syntax



Game Maker: Error Messages (1 of 2)

Pay attention!
Refers to:
-Object
-Event
-Line number
-Variable name

- Help pinpoint problem
  - Refer to object and method and offending code

Game Maker: Error Messages (2 of 2)

- Can write messages to log file
- Can ignore messages
  - Use "error_last" and "error_occurred" for custom handling
  - Typically, use only in release

Debugging Tips (1 of 3)

- *Fix one thing at a time*
  - Don't try to fix multiple problems
- *Change one thing at a time*
  - Tests hypothesis. Change back if doesn't fix problem!
- *Start with simpler case that works*
  - Then add more complex code, one thing at a time
- *Question your assumptions*
  - Don't even assume simple stuff works, or "mature" products
  - Ex: libraries and tutorials can have bugs
- *Minimize interactions*
  - Systems can interfere, or make slower, so isolate the bug to avoid complications

Debugging Tips (2 of 3)

- *Minimize randomness*
  - Ex: can be caused by random seed or player input. Fix input (script player) so reproducible
- *Break complex calculations into steps*
  - May be equation that is at fault or "cast" badly
- *Check boundary conditions*
  - Classic "off by one" for loops, etc.
- *Use debugger*
  - Breakpoints, memory watches, stack …
- *Check code recently changed*
  - If bug appears, may be in latest code (not even yours!)

Debugging Tips (3 of 3)

- *Take a break!*
  - Too close, can't see it
  - Provide fresh prospective
- *Explain bug to someone else*
  - Helps retrace steps, and others provide alternate hypotheses
- *Debug with partner*
  - Provides new techniques
  - Same advantage with code reviews, peer programming
- *Get outside help*
  - Tech support for consoles, Web examples, libraries, …

Tough Debugging Scenarios and Patterns (1 of 3)

- Bug in *Release* but not in *Debug*
  - Often in initialized code
  - Or in optimized code
    - Turn on optimizations one-by-one
- Bug in *Hardware* but not in *Dev Kit*
  - Usually dev kit has extra memory (for tracing, etc.). Suggests memory problem (pointers), stack overflow, not checking memory allocation
- Bug Disappears when Changing Something Innocuous
  - Likely timing problem (race condition) or memory problem
  - Even if looks like gone, probably just moved
    - Keep looking!

Tough Debugging Scenarios and Patterns (2 of 3)

- Truly Intermittent Problems
  - Maybe best you can do is grab all data values (and stack, etc.) and look at ("Send Error Report")
- Unexplainable Behavior
  - Ex: values change without touching. Usually memory problem. Could be from supporting system. Retry, rebuild, reboot, re-install.

Tough Debugging Scenarios and Patterns (3 of 3)

- Bug in Someone Else's Code
  - "No it is not." Be persistent with own code first.
  - Find concrete support for your claim!
    - Small reproduction case
  - It's not in hardware
    - Ok, very, rarely, but expect it not to be, unless you are designing the hardware too!
    - Download latest firmware, drivers
  - If really is, best bet is to help isolate to speed others in fixing it
  - Meanwhile, you probably need to find a workaround or alternative
    - There is usually more than one way to write the code you want!