Introducing Computer Programming via Gameboy Advance Homebrew

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Introduction

Introduce young students to computer science and engineering

Target 5th - 8th grade students

- After appropriate level of abstract thinking
  - Programming requires abstraction
- Before influence of social stereotypes
  - This can impact student's desire to learn

But try to appeal to a much wider audience

Goals

How computers work

- Demystify computers
- Connection between software/hardware

How to program

- Get comfortable with idea of programming
- Ignite spark of interest

Our approach

Motivate students with compelling goal

- Create GBA/NDS game, runs on real device
- “Homebrew” development

Provide real programming environment

- No sandbox or limitations

Connect software with underlying hardware

- Provide context for programming

Enhance “ownership” of programming project

Compelling goal

"Would you like to learn how to create your own Gameboy Advance/Nintendo DS game?"

Highly motivating for broad range of students

- From pre-K to college (and beyond)

GBA/NDS is first real electronic device

- Not a kid's toy

vs

Complete environment

No restrictions on what you can do

- “Keys to the kingdom”

Important for teenagers

- Easy to recognize playground environment
  - Can be de-motivating
- Sensitive to situation where they are not treated as an adult

Connect software and hardware

GBA is relatively simple

- No OS or VM between program and device
- Manipulate hardware registers

NDS is slightly more complex

- GBA + additional hardware (touchscreen)

Easy to make connection to hardware

- References made throughout class

Enhance ownership

Strongly believe that students should create all their own graphics

- Important for motivation
- Increased sense of ownership/accomplishment
- Implies that we need to start with 2D

Compare with 3D programming worlds:

- Students forced to rely on pre-generated models

What is “homebrew” software?

Homebrew software is:

- Written for proprietary hardware systems
  - Not typically programmable by end-users
  - Usually requires official devkit ($$$)
- Created by non-professionals (end-users)
  - “Hobbyist” programmers

Homebrew community

Requires:

- Development tools to be created
- The system to be reverse-engineered
- Homebrew community for each system

Tools made available to the community

- For Free

All major systems have a homebrew community

- With varying degrees of success

GBA/NDS homebrew

Mature homebrew community:

- Development tools:
  - devkitPro (devkitARM for GBA/NDS)
  - Various text editors/IDEs
  - Various graphic editing tools

- Emulators:
  - GBA: VisualBoyAdvance, no$gba
  - NDS: no$gba, DeSmuME, Dualis, iDeaS

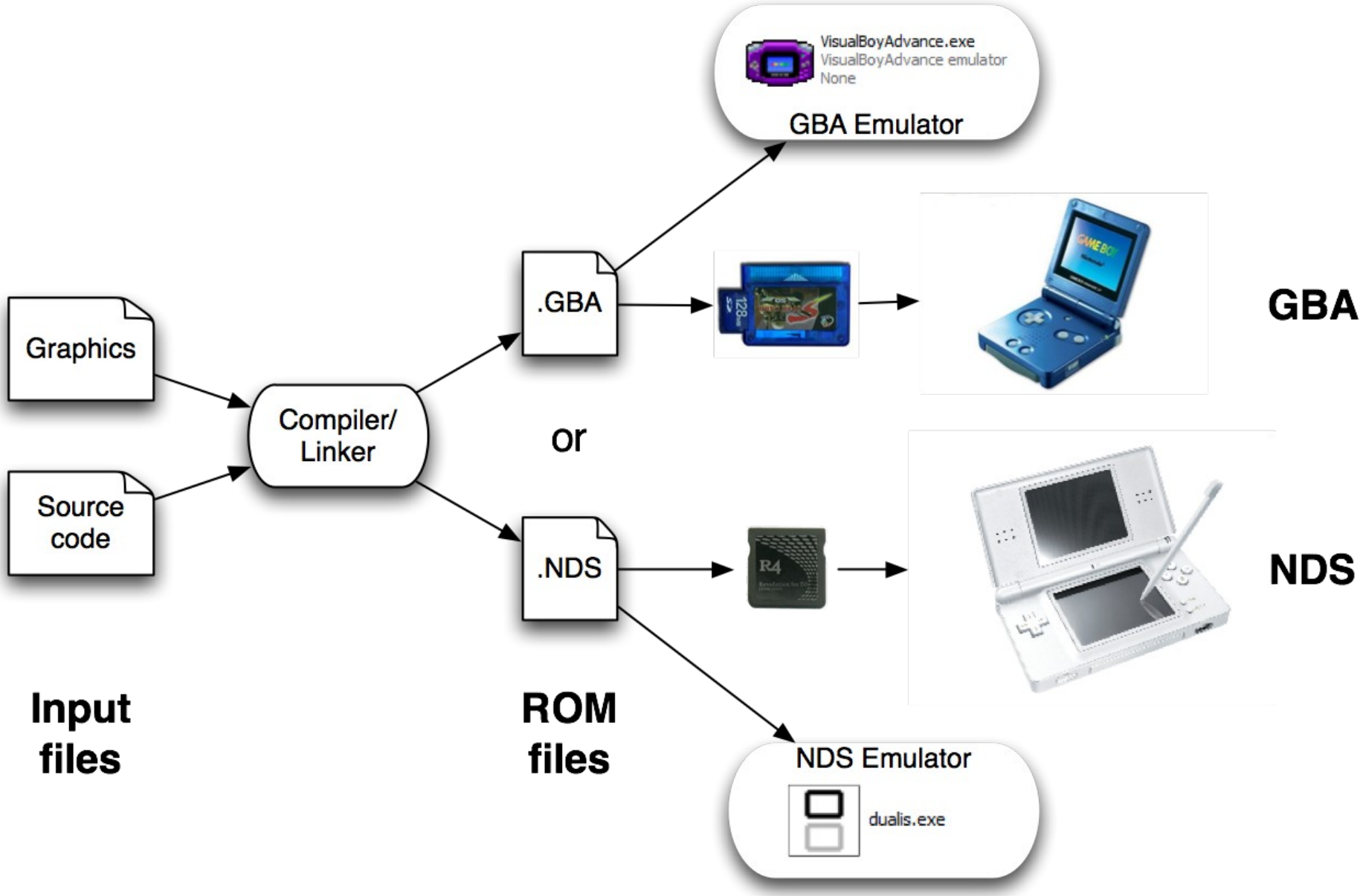
GBA/NDS cartridges

Run projects on real hardware

- GBA: SuperCard, MoviePlayer, ...

- NDS: R4, M3, DSTT, CycloDS, DSLinker, ...

Homebrew development flow



Homebrew caveats

Homebrew dev tools are not “friendly”

- Can be difficult to work with at first
  - Assume familiarity with command line
- Debugging environment is not ideal
- Not created with elementary students in mind

Once set up, however, it's straightforward

- With one exception:
  - Integrating graphics into your game

Graphic editing tools

Lots of 2D tile/map editors and conversion tools

- Mappy, Tiled, gfx2gba, …

Two broad categories:

- General purpose graphical tools
  - Need to select options to work on GBA/NDS
- Command line tools:
  - gfx2gba -D -fsrc -psprite.pal -t8 sprite.bmp
  - grit sprite.bmp -Mw 2 -Mh 4 -gB4 -pe 16 -U16 -ftc

Graphic processing

Problem:

- Need to import graphic files
- Process is error-prone

Solution:

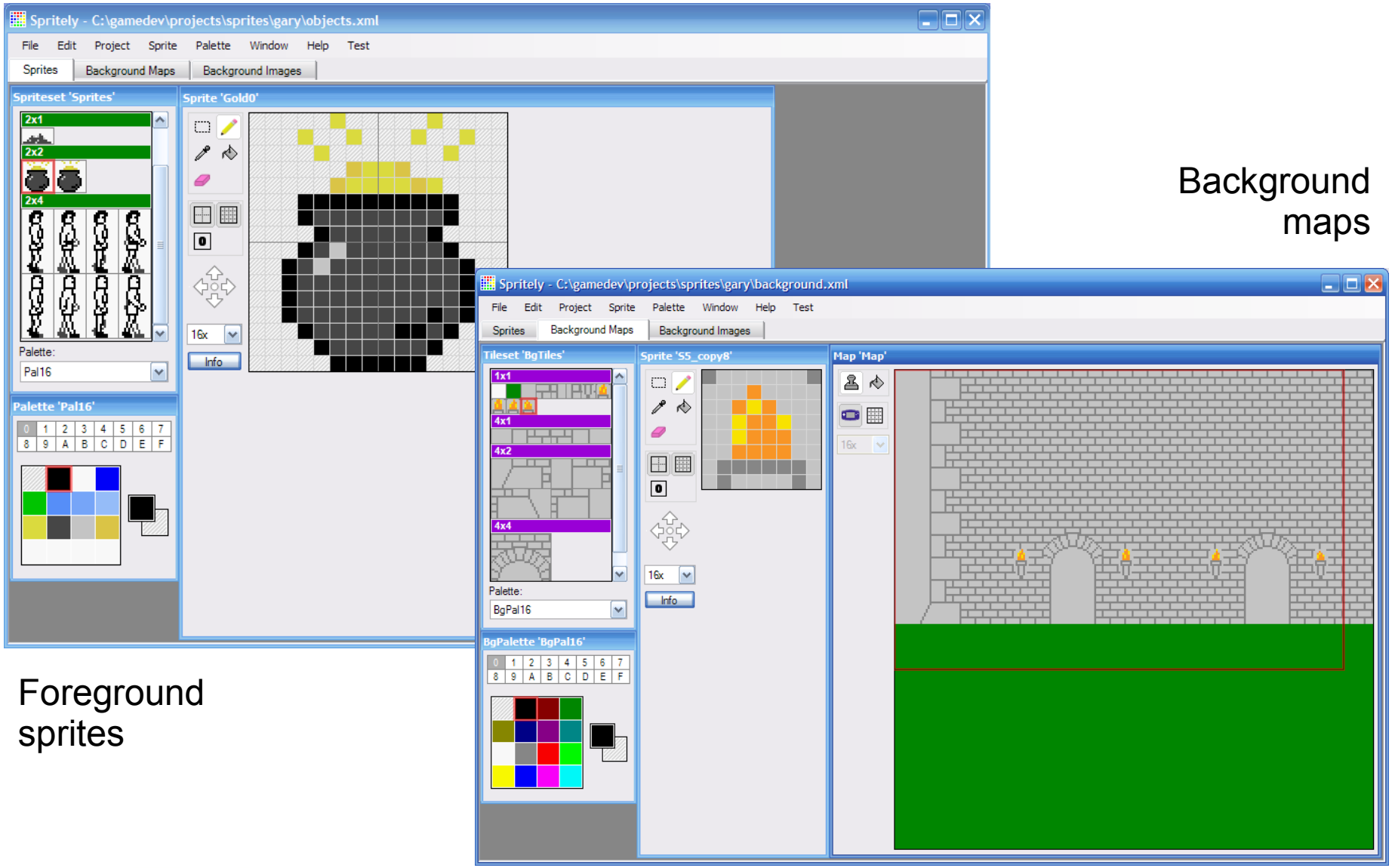
- Create tool specific for task

Spritely

Spritely is a tile/sprite/map editor

- Specifically for GBA/NDS
- Prioritize features for beginner game developers
- Students cannot make conversion mistakes

Spritely sprite/map editing



Background maps

Foreground sprites

Spritely Project Export

Can also export complete GBA/NDS project

- Starter project:
  - Draw > Export > Compile > Run
- Used as baseline for their own projects

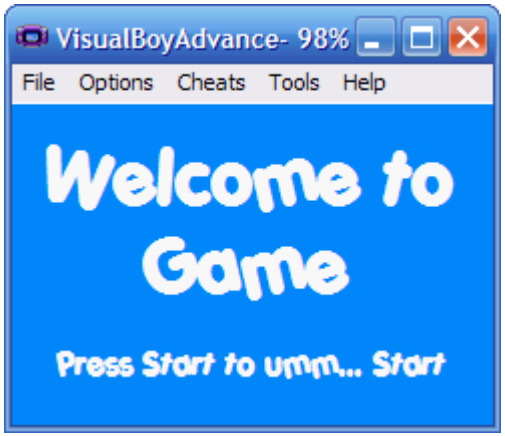
Spritely Demo

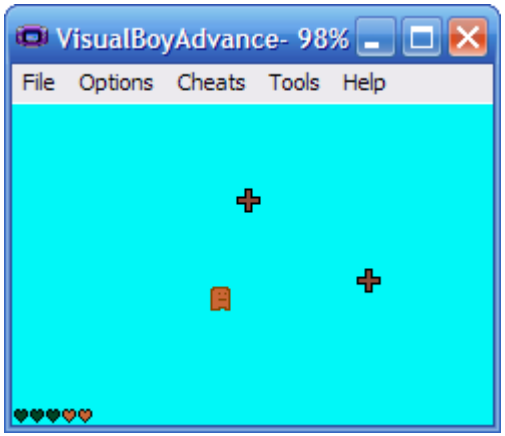
Spritely Tutorials

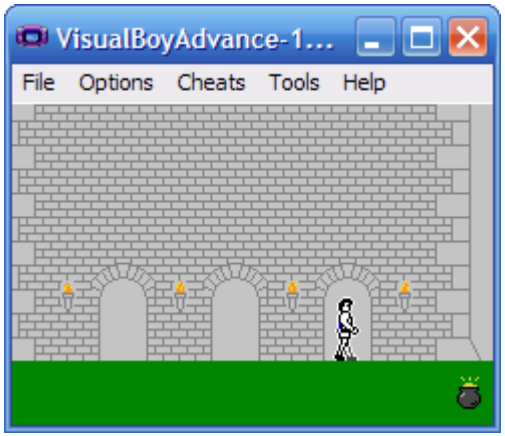
Programming structured as a series of tutorials:

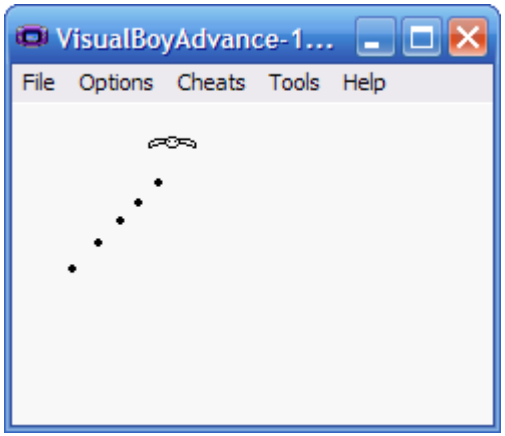
- Creating a ROM
- Creating and animating objects
- Collisions
- Projectiles & multiple projectiles (arrays)
- Gathering objects
- Levels (including title/game-over screens)
- Pong
- ...

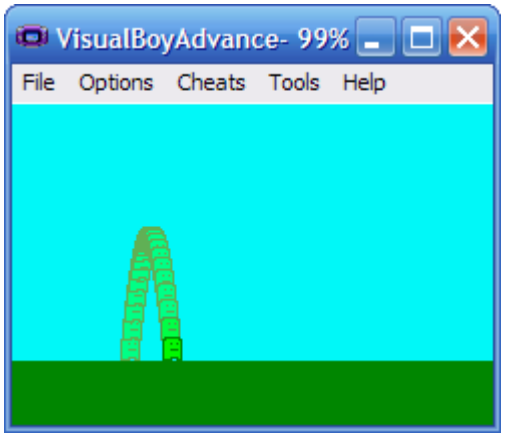
Sample tutorial projects

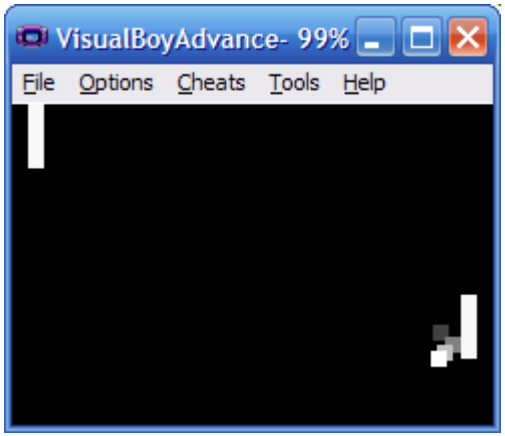




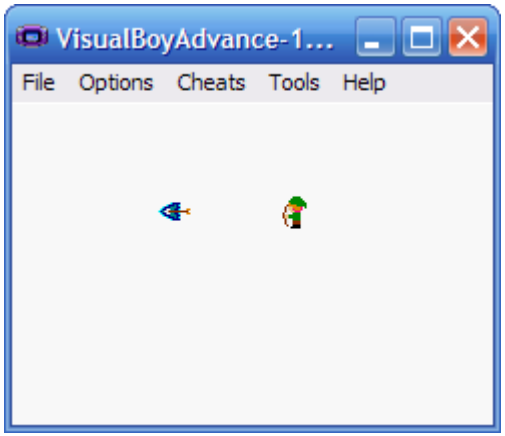


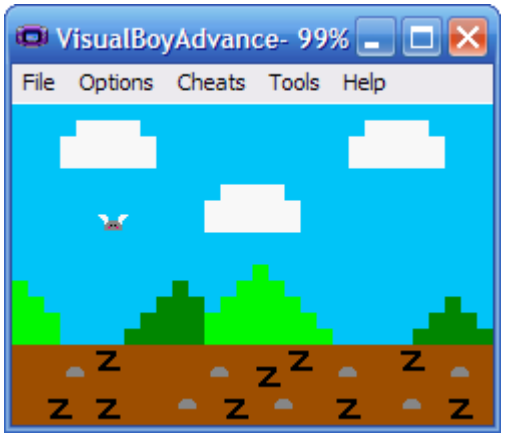


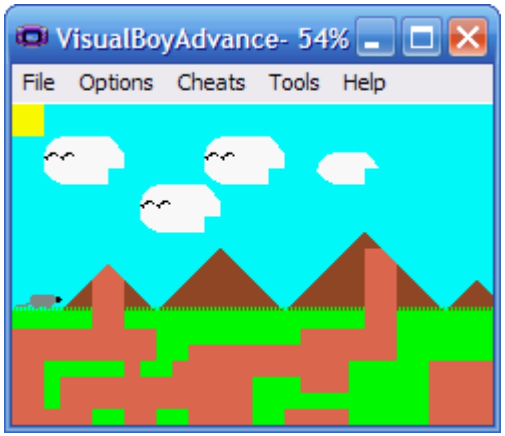


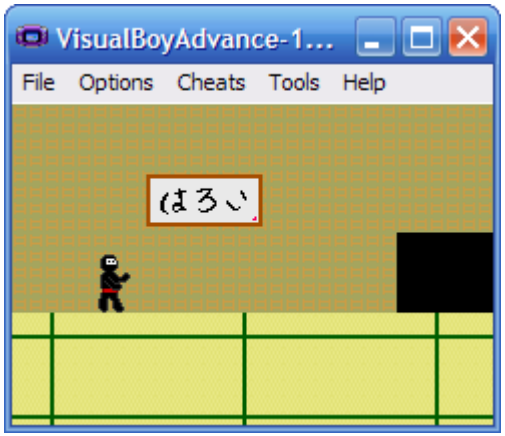


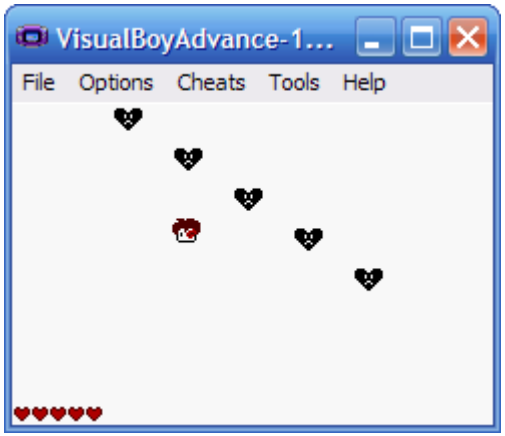
Sample student projects











Tutorial challenges

Two challenges with tutorials:

- Presenting code
  - Best way to present code edits in tutorial
- Keeping the tutorials up-to-date
  - Spritely is under development and changing

Presenting code

Students are unfamiliar with editing code

- Need to provide sufficient context

Custom Javascript pretty-printer to add annotations to code:

Step 5 : Adjust for size of player sprite

Make the following changes:

game_state.cpp — Lines 94 - 116:

```
        // If we need to move the player.
        if (dx != 0 || dy != 0) {
            // Calculate the player's new location.
            int x = _xPlayer + dx;
            int y = _yPlayer + dy;

            // Get the width/height of the player.
            int width, height;
            GetObjectSize(kObj_Player, &width, &height);

            // Don't let the player go outside the screen boundaries.
            if (x < 0 || x > SCREEN_WIDTH - width)
                dx = 0;
            if (y < 0 || y > SCREEN_HEIGHT - height)
                dy = 0;
```

Keeping tutorials up-to-date

Developing Spritely and tutorials simultaneously

- Feedback to improve program/tutorials
  - Restructure generated code
  - Add/remove base functionality

Don't break existing tutorials

- Need to constantly validate tutorials
- Easy with 1-2, challenging as you add more

Automated tutorial verification

Class organization

Class was offered as:

- A series of 1 hour classes after school
- ~32 weeks
- Small class size:
  - 8 students: 6 girls, 2 boys

Broad range of topics

Pre-programming skills

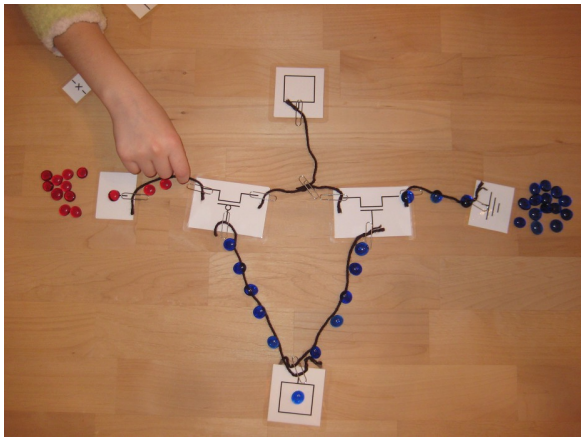
- Number systems, boolean logic

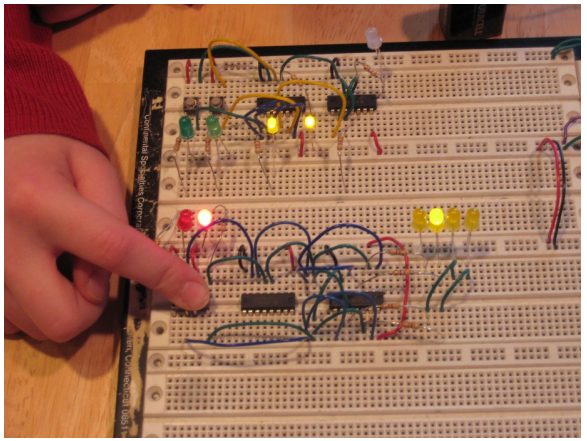
Digital hardware

- n/p-type MOSFETs, CMOS
- Hardware lab

Basic programming

- Variables, control flow





GBA/NDS Programming

GBA/NDS programming in 2nd half of class

References made to GBA/NDS throughout:

- Number systems
  - Draw 8x8 bitmaps and convert base 2 & 16
- Memory
  - Show how GBA carts map into upper address
- Hardware
  - Disassemble GBA

Programming Project

Lure/trick students into programming

- Start out with basic tutorials
- Continue by drawing sprites/maps for project
  - Students invest themselves in project
- Let student drive
  - “How can I...?” leads to related tutorial
  - Also peer driven “How did you do that?”

Evaluation

Goal is to spark interest in programming

- How do you measure that?

Un-prompted metrics:

- Observed in students without prompting
- Instead of asking if they would recommend the class, we observe whether or not they did

5 metrics:

- Drop, Recommend, Relate, Debug, Program

Evaluation

5 metrics:

- Drop – Did not complete class = 25%
- Recommend – Recommended class = 63%
- Relate – Related class info outside = 75%
- Debug – Independent debugging = 50%
- Program – Independent programming = 25%

Observed metrics, will tend to under-report

Conclusion

Overall:

- Successful in motivating students

But

- Approach not appropriate for all situations
- Teacher intensive, best with small class size
- Should probably follow visual programming:
  - Scratch, Alice, ...

We're releasing tools, tutorials & other materials

Questions?

Spritely and tutorials:

- http://code.google.com/p/spritely

Still under development

We welcome feedback/comments