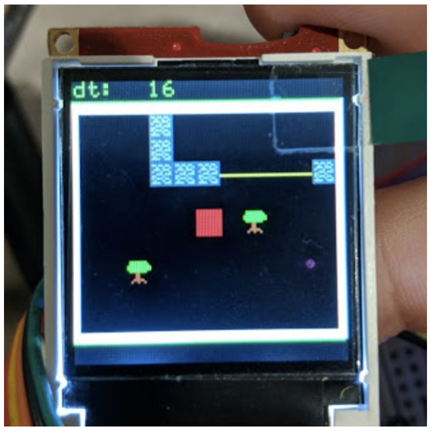
GTLegend: A Role-Playing Game

The goal of this project is to build a Quest game on the Mbed platform, therefore fulfilling your life long goal to be a video game designer. Since the very first video game platforms, top down role-playing games (RPGs) have held an important place in the video game corpus. Such notable titles as *The Legend of Zelda* and *Pokemon Red Version* are exemplars of this style. In this project, you will build a handheld top-down RPG game using the gaming circuit constructed during HW3 and your P2-1 hashtable implementation.



In your top down RPG, the protagonist will be controlled by tilting the game board; the accelerometer will be used as the input for character motion. The buttons will be used to trigger actions in the game. Crucially, the map area of the game will be much larger than the area you are able to display on the screen. Objects on the map will be stored in a hash table, and you will look up the correct locations to display them at every game update.

There are several basic features that your game must implement in order to receive baseline credit; advanced features are an opportunity to earn full and possibly extra credit. The list of basic features and examples of some advanced features are given below. (See rubric for grading details.)

Basic Features

These features are for baseline credit and constitute a functional, but minimal, adventure game. Please note that the story, art, and actions available in the game are intentionally vague, and the specific design of the game is up to your creativity. RPG games are extremely varied, and this project is an opportunity for you to make something unique. Have fun with it!

Player Motion & The Map

The Player character in this top-down RPG moves around in the direction of the tilt of your breadboard, as measured by the accelerometer.

The Map for your game is the world that the character moves around in. The Map is made up of individual tiles, and a grid of 11 x 9 tiles is displayed on the screen at any time. The character is always displayed in the center of the screen. The Map should be at least 50 x 50 tiles, and should have walls around the edges to prevent the Player from leaving the map. The Player should not be able to walk through the walls.

You will need to populate the Map with Items relevant to your game - these Items can include scenery, walls, Non-Player Characters (NPCs), objects, stairs, etc. Implementation details for the Map are discussed in detail in the accompanying technical document.

World Interaction

There are several buttons available in the hardware setup created in HW3. Two of them have required functions:

1. **Action button:** This is the primary way the player interacts with the world. Pressing this button will initiate conversation with NPCs, scroll speech bubbles, unlock doors, etc. The particular action triggered when this is pressed depends on the player's location in the world. For example, pressing the action button while standing near the door and holding the key would trigger unlocking the door.
2. **Omnipotent-Mode button:** When this button is pressed, "Omnipotent Mode" is toggled. When in Omnipotent Mode, the character should be able to walk anywhere in the world. This is to facilitate grading. For example, if for some reason the door won't unlock even when you're holding the key, your grader can still continue with the quest.

You are free to use the remaining buttons for any features of your choice. These might be useful to open a menu, for example.

The Quest

The meat of this game, as with all good RPG games, is a quest! In order to win, the Player must complete a quest by interacting with characters and objects in the world in order to obtain a key and pass through a locked door.
The quest proceeds in five steps:

1. Talk to an NPC to start the quest. The NPC gives the Player instructions to complete a task in a different Map (in a house, in a cave, in a lake, etc.).
2. In the new Map, the Player has to solve a puzzle, by interacting with the Items in the Map. Note that the Player can also be part of the game (e.g., Player is a piece of a chess game).
3. Talk to same NPC again to complete the quest. The NPC will give the player a key as a reward.
4. Find the locked door, and use the key to open it.
5. Walk through the door and interact with something: a chest, a throne, etc. You win! Display a game over screen.

All of the interactions in the quest should be triggered by the action button when standing near the target and should show a speech bubble that delivers the supporting storyline. For example, to begin the quest the player should stand adjacent to the NPC and press the action button, triggering Step 1 and displaying a speech bubble with instructions for Step 2. Speech bubbles should cover the bottom part of the map and should scroll when the player presses the action button. More detail on their implementation is given in the technical document.

The NPC must say different things in these states:

1. Starting the quest (Step 1: First time talking to the NPC)
2. Quest incomplete (Step 2: After Step 1 is complete, but Step 2 incomplete)
3. Quest completion (Step 3: Giving the key)
4. After quest complete (Beyond Step 3)

The door must block player motion when closed, and should be visually different once it is opened. (This difference can be as simple as the door disappearing from the map, or it can be different art showing an open door). The door should give some indication that you're trying to open it, such as a speech bubble or visual animation, and it should respond differently when the character has/has not obtained the key. Your door must block the player if the player doesn't have a key, and it should only open when the player presses the action button while holding the key.

Graphics

You should put some effort into making your game look good! At least one sprite is required as a basic feature. A sprite in this context is a tile that's more than just a rectangle. You should be using the `uLCD.BLIT` or `draw_img` functions to accomplish this.

A status area is set aside at both the top and bottom of the screen. The top status area should display at a minimum the current player coordinates within the map. These areas can also be used to show information such as quest progress, character inventory, what the action button will do at this location, etc.

For clarity while the Player is moving, it's a good idea to have some background items on the map that scroll by as the player moves. The trees in the demo fulfill this purpose. This is not strictly required, but you'll probably want to add it.

Basic Feature Summary:

1. Accelerometer moves the player.
2. Walls block character motion.
3. Omnipotent-mode button walks through walls.
4. The first map must be bigger than the screen (at least 50*50 tiles).
5. Stairs/ladders/portals/the door go between the first and the second map.
6. Quest works (key & door work).
7. Display game over screen when quest is complete.
8. Status bar shows player coordinates.
9. Speech bubbles are used in the quest.
10. Art includes at least one sprite.

Advanced Feature Examples

Advanced features in this project are open ended and allow you to make the game your own. The features listed below are all acceptable, but this is not an exhaustive list. Other features that are at or above the difficulty level of those listed here are acceptable. Each extra feature is worth +5 points, and you must tell your grader before the demo begins which extra features you used.
There will be a pinned discussion topic on Piazza to confirm extra features. If you intend to use features that aren't listed here, start a follow-up on this discussion to clear it with the TAs or instructors before grading begins.

- Add a start page
- Sound effects for interactions / background music

- Different modes of locomotion (e.g., running, hopping, etc.) They should be visually distinctive.
- Animation for interactions with things in the map (e.g., exclamation mark above NPC when you are talking, apple trees look different when apples are picked off etc.).
- In-game menu:
    - Save the game
    - Show status information
    - Configuration (Accelerometer direction, which button is which, etc.)
- Multiple lives and the possibility to lose:
    - Health & stuff that hurts you.
    - Spikes, enemies, etc.
- Player can manipulate items in game
    - Push a boulder around to complete the quest.
    - Blowup/destroy something.
- Mobile (walking) NPCs.
- Player plays against an intelligent opponent in a game.
- Save the game (persistent over power-off)
- Multiple quests (>=2), or extra NPC relevant to the quest(s) (>=5). Only applicable once.
- Bigger objects in the map that blocks the character.
    - A very tall tree that hides the character.
    - A feature you can walk behind/under such as a bridge.

P2-2 Technical Reference

In this project, you'll be combining hardware interface libraries for an LCD screen, pushbuttons, speakers, and an SD card reader into a cohesive game. The shell code has several different modules. This document is intended to be a reference for various technical considerations you'll need when implementing your game.

Hash Table

The game will make use of your HashTable library, implemented in P2-1. In order to use this library within the Mbed environment, the easiest strategy is to simply copy and paste the code into the correct files. The shell project has two files already for this purpose: hash_table.cpp and hash_table.h. Copy your completed code from P2-1 into these files before starting anything else.

USB Serial Debug

Debugging is an important part of any software project, and dealing with embedded systems can make debugging difficult. Fortunately, there is a built-in serial monitor on the Mbed that allows you to see printf-style output from the Mbed on your computer. The tutorial to set that up can be found here:

https://os.mbed.com/handbook/SerialPC

The Serial pc object described in the tutorial is already set up for you in globals.h, so you won't need to declare it again. Any file that includes this header can print to the USB like so:

```
pc.printf("Hello, world!\r\n");
```

Game Loop Overview

The basic structure for organizing a video game is called this *game loop*. Each iteration of this loop is known as a *frame*. At each frame, the following operations are performed, typically in this order:

1. Read inputs
2. Update game state based on the inputs
3. Draw the game
4. Frame delay

You'll be implementing parts of each of these steps, along with setting up the game loop to call them in the correct order. The game loop shell code with timing already implemented is in main.cpp.

Read Inputs. Reading user input for a frame happens only once during the frame. This serves two purposes. For one, it isolates the part of the code that has to deal with the input hardware to just the read_inputs function, allowing the rest of the code to deal with only the results of the input operation. Secondly, it ensures a constant value of the "true" input for a particular frame. If there are multiple parts of your game update logic that have to interact with the inputs, it is convenient to know that these inputs are guaranteed to be the same

Update game. This is where the magic happens. Based on the current state of the game -- where the Player is standing, whether the player is holding the key, what the NPCs are doing -- you compute what the next state should be, based on the inputs you've already measured. For example, if the accelerometer is tilted toward the top of the screen, the Player should move up in the map. This is where most your development will be focused.

Draw game. With the state updated, you now need to show the user what changed by drawing it to the screen. This step is discussed in much more detail below, but for now you'll want to know that the entry point to this portion of the code is called draw_game.

Frame delay. By default, loops in C run as fast as the instructions can possibly execute. This is great when you're trying to sort a list, but it's really bad for games! If the game updates as fast as possible, the user might not be able to understand what's happening or control the character appropriately. So, we introduce a delay that aims to make each frame take 100ms. The time for all the proceeding 3 steps is measured, and the remaining time is wasted before starting again. If more than 100ms has already passed, no additional delay is added. As you're developing your game, be careful that your frames don't get too long, or the feel of your game will degrade.

Map Module

In order to think about updating the game state (moving the player) and drawing the screen, we first need some way to represent the world. This module accomplishes that task.

The map is a two-dimensional grid whose origin is at the top-left corner of the world. The X coordinate increases toward the right, and the Y coordinate increases toward the bottom. This left-handed coordinate system is chosen for consistency with the graphics; see that section for more details. The finest granularity of the map is a single grid cell; the player moves from cell to cell, and each cell contains at most one MapItem. If the cell is empty, then that cell is free space on the map.

The map in this game is represented by a collection of MapItems held in a HashTable. The keys in the HashTable are (x,y) pairs. The data in the HashTable are all of type MapItem, defined in map.h. So, for example, if you access the key "(10, 23)" in the HashTable and the data is a MapItem whose type is WALL, then the player should not be able to walk into that cell.

The shell code is written so that the use of the HashTable is hidden inside the map module; that is, the hash_table.h is only included from map.cpp, and the HashTable functions are only used internally to that module. The public API of the map module does not expose the HashTable, since this is an implementation detail of the map and does not affect the rest of the game. This hides the complexity of the HashTable (questions like "what is the best hash function?" and "how do I map (x,y) pairs into integer keys for use in my hash table?") within the map module itself, and simplifies the rest of the game logic.

The public API for the map module is given in map.h. All functions and structures are documented there. There are functions for accessing items in the map (e.g. get_here, get_north), modifying the map (e.g. add_wall), and selecting the active map. *You are encouraged to add more functionality to this API as you deem necessary for your game.* The point of an API is to be useful to the programmer; if these functions are insufficient, add more!

Map Items. This is the basic unit of the map, and is the underlying type of all the void* data in the map HashTable. Each MapItem has an integer field, type, which tells you what kind of item it is. This allows you to store different information in the map, such as the location of walls and the location of trees, using the same data structure. Each MapItem also has a function pointer of type DrawFunc, that will draw that MapItem. Its inputs are a pixel location (u,v) of the tile. Finally, each MapItem has two additional parameters: an integer flag, walkable, that describes if the player is allowed to walk on that cell; and a void* data for storage of any extra data required during the game update. Walls probably don't need extra data; NPCs or stairs or the door might.

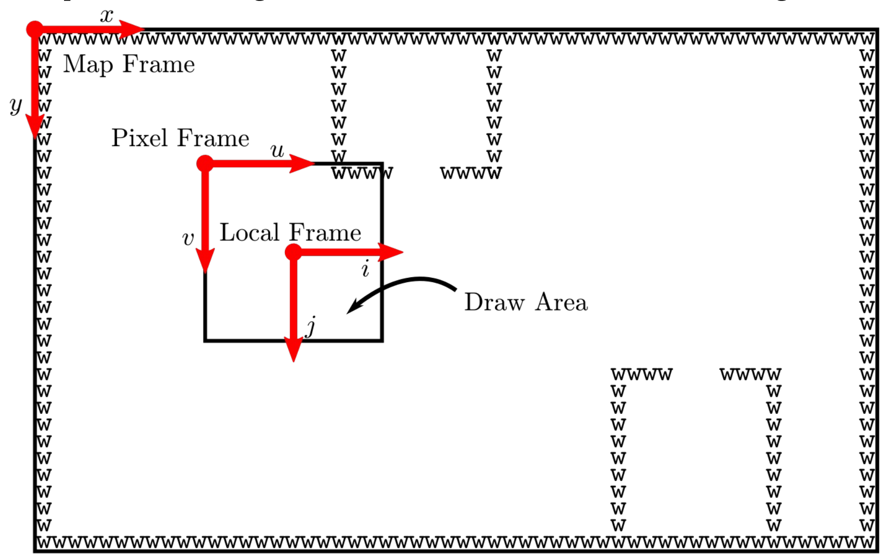
Two-dimensional keys. As you implemented in P2-1, the HashTable accepts only unsigned integers as keys. However, for this application you need to use two integers (the X & Y coordinates) as the key. In order to do this, you need to have a functions to map these coordinates unambiguously into a single integer. This function is called XY_KEY, and is private to map.cpp. You then also need a hash function that will take this key as normal and produce a hash value for bucket selection in the HashTable.

The Active Map. All operations in the Map API use the "active map." In the shell code, there is only one active map. The function get_active_map returns this map, and the function set_active_map does nothing. As an advanced feature, you may modify these to allow selection between multiple maps. Once an active map is selected using set_active_map, all other functions (accessors and modifiers) will use the currently active map. Only one map can be active at a time; setting a new active map implicitly deactivates the previous active map.

Graphics

The graphics module houses most of the drawing code for the game. This includes all the drawing functions for the various MapItems. The entry point for drawing the screen under normal operations (not in a speech bubble) is the draw_game function. This section describes how that function accomplishes drawing the tiles, and various ideas to consider as you extend this function for your own game.

Coordinate Reference Frames. There are several relevant coordinate frames for this game. The first we have already covered: the map frame. This frame's coordinates are labelled (x,y) and its origin is the top corner of the map. X increases right, and Y increases down. All frames in the game are this left-handed



orientation.

The next frame is the local drawing frame. This frame is centered on the Player, and ranges from (-5,-4) to (5,4), i.e. it is an 11x9 grid of cells. This frame is iterated in draw_game and each cell in drawn in turn using the DrawFunc from the map, or a draw_nothing function if there is no MapItem. The coordinates of this frame are labelled (i, j).

Finally, there are the pixels on the screen. This frame has its origin at the top-left corner of the screen. The screen is at 128x128 array of pixels. The coordinates of this frame are labelled (u,v). Each cell in the map is 11x11 pixels.

Drawing functions. As noted above, each MapItem has an associated DrawFunc that knows how to draw that item. These functions take as input a (u,v) coordinate for the top-left pixel of the tile, and draw an 11x11 image that represents the MapItem. An example is the draw_wall function, in graphics.h.

You will need to add more draw functions as you add more types of MapItem. You are free to implement these however you like, using the full power of the uLCD library. However, a simple way to do this has been given to you. The draw_img function takes a string of 121 (= 11 * 11) characters, each representing a pixel color, and translates that into a BLIT command to draw those colors to the screen. You can use this function to make nice graphics very simply by defining a new string that represents the image you want to draw. This is the recommended method for generating art for your game.

Drawing Performance. The screens are notoriously slow to draw, and the length of time it takes to complete a drawing command is proportional to the number of pixels that it changes on the screen. So, the drawing code goes through some hoops to make sure that things keep moving quickly. In particular, the drawing code requires not only the current player position (Player.x and Player.y) but also the previous position (Player.px and Player.py), in order to determine what has changed on the screen. If an element on the screen has not changed, it is not redrawn. This saves time and make the game update more quickly. You'll need to be careful with this as you decide how many items to put in your map and how to draw the new items you add.

You must design, implement, and test your own code. There are many, many ways to code this project, and many different possibilities for timing, difficulty, responsiveness and general feel of the game. Your project should represent your interpretation of how the game should feel and play. Any submitted project containing code (other than the provided framework code and mbed libraries) not fully created and debugged by the student constitutes academic misconduct.

Mbed reference materials: http://ece2035.ece.gatech.edu/readings/embedded/index.html