



*DB in Telecommunication Technologies and Data Science*

Programming 24/25

Group 196

*Final Project*

“Bottle Bros.”

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## 1. Summary

This document describes the design and implementation of a 2D game inspired by Nintendo's Mario Bros. LCD Game & Watch title, developed in Python using the Pyxel retro game engine.

The report explains the main classes, core algorithms (movement, collision, state management), the development process and decisions taken, as well as the current functionality, missing features, and extra improvements added over the basic requirements.

With this project we attempt to learn the fundamentals of Object-Oriented Programming and grasp the concepts necessary to develop our skills in coding and problem-solving.

## 2. Introduction

The goal of this project was to design and implement a small but complete video game in Python, applying Object-Oriented Programming (OOP), basic game loop structure and state management. The chosen concept is a recreation of the classic LCD Mario Bros.

The game is set in a factory, Mario and Luigi move boxes between conveyor belts to load a truck, while avoiding drops and handling increasing difficulty.

Pyxel was selected as the main library because it provides a simple framework for pixel-art games: screen management, sprites, keyboard input and a fixed-rate update/draw loop.

The project also aims to practice modular design by separating the code into classes such as Board, Character, Conveyor, Package and Truck, plus a configuration module config for constants and sprites.

### 2.1. Game description

The game takes place in a factory where Mario and Luigi must move boxes along several conveyor belts to load them into a truck. The player controls each character's vertical position so they can catch and pass boxes in time, avoiding breaks; each delivered box increases the score, while each broken box increases the fail counter, and the game ends when three fails are reached.

### 3. Design and Architecture

In this section we will discuss the different classes in which we have separated our game and the main functionality that resides in each of them. We will provide an overview of the methods and attributes along with the class diagram showing the relation between classes.

#### 3.1. Main

Application entry point and integration with the Pyxel engine.

- Attributes:
  - board: Board - Main game controller.
- Most relevant methods:
  - `__init__()` - Initializes Pyxel (window, FPS, resources) and creates the Board instance.
  - `update()` - Called every frame by Pyxel; forwards to `board.menu_update()` and `board.update()` when the menu is not active and the game is not over.
  - `draw()` - Clears the screen, calls `board.draw()`, and, if needed, draws the menu or the game-over image.

#### 3.2. Board

Central game controller. Manages state, difficulty, characters, conveyors, packages, truck, boss and menu.

- Main Attributes:
  - Game state: difficulty, score, fails, game\_over.
  - UI state: menu\_active, \_\_menu\_selected.
  - Entities: mario: Character, luigi: Character, truck: Truck, conveyors: list[Conveyor], packages: list[Package].
  - Difficulty / progression: \_\_number\_of\_conveyors, \_\_conveyor\_speed, number\_of\_packages, \_\_points\_for\_package, \_\_number\_of\_deliveries.
  - Boss system: boss\_active, boss\_target, boss\_timer.
- Most relevant methods:
  - Boss system: boss\_active, boss\_target, boss\_timer.
  - `menu_draw()` / `top_menu()` - Draw menu and HUD (score, fails, buttons).
  - `difficulty0()`, `difficulty1()`, `difficulty2()`, `difficulty3()` - Configure conveyors, speeds and scoring per difficulty
  - `update()` - Per-frame logic: check difficulty, update truck delivery and boss punishment, and when no special state is active update characters, generate and move packages, and check game-over.
  - `draw()` - Draw conveyors, packages, platforms, truck, characters, boss, and UI.

### 3.3. Character

Represents Mario or Luigi, with movement and sprite/animation.

- Main Attributes:
  - character: str – “MARIO” or “LUIGI”.
  - level: int – Current vertical level/platform.
  - has\_package: bool – True if carrying a box.
  - resting: bool – True during truck deliveries.
  - reprimand: bool – True when being punished by the boss.
- Most relevant methods:
  - `__init__(character: str)` – Initialize character type and default state.
  - `update(max_level: int)` – Handle input (different keys for Mario and Luigi) and change level when not resting or reprimanded; update animation state.
  - `draw()` – Draw character sprite on screen according to level and current state.

### 3.4. Conveyor

Represents a conveyor belt with a given speed.

- Main Attributes:
  - level: int – Conveyor index/height-
  - speed: float – Movement speed for packages on this belt.
- Most relevant methods:
  - `__init__(level: int, speed: float)` – Configure conveyor level and speed.
  - `draw(game_over: bool)` – Draw conveyor tiles using config sprites.

### 3.5. Package

Represents a moving box on the conveyors.

- Main Attributes:
  - level: int – Current conveyor level.
  - speed: float – Horizontal movement speed.
  - state: str – “CONVEYOR”, “HANDLED”, “BROKEN” or “TRUCK”
- Most relevant methods:
  - `update()` – Move the package according to its speed and state.
  - `at_the_end()` -> bool – Check if the package has reached the end of its current conveyor.
  - `move_to_next_conveyor()` – Move package to the next conveyor when handled correctly.
  - `broken()` – Mark the package as broken.
  - `draw()` – Draw the package with the appropriate sprite.

### 3.6. Truck

Collects delivered packages and manages the delivery timing.

- Main Attributes:
  - number\_of\_packages: int – Number of boxes loaded (0–8).

- ▶ state: str – “LOADING” or “DELIVERY”.
- ▶ delivery\_start\_frame: int | None – Frame when delivery started (for timing).
- Most relevant methods:
  - ▶ start\_delivery() – Switch to “DELIVERY” and record current frame.
  - ▶ delivery\_done(duration\_frames: int = 180) -> bool – Check if delivery time has elapsed.
  - ▶ finish\_delivery() – Return to “LOADING”, reset timer and empty the truck.
  - ▶ draw(level: int) – Draw truck head and bed depending on number\_of\_packages.

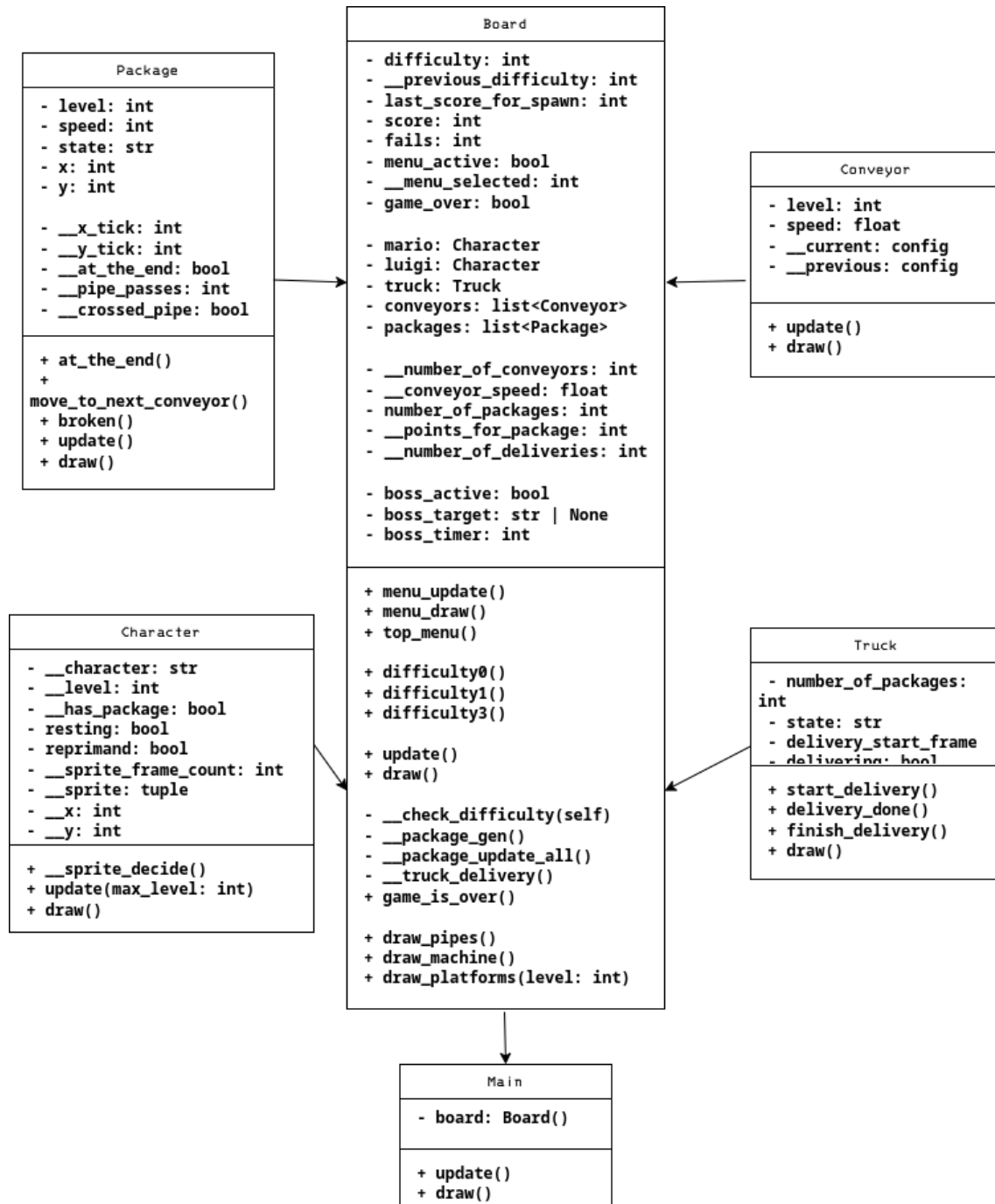


Figure 1: Class diagram.

## 4. Main algorithms

In order to provide a well-functioning game, we designed algorithms that manage the game logic while providing structure and cohesion to the whole codebase.

### 4.1. Game loop

The game loop is managed by Pyxel, which repeatedly calls `Main.update()` and `Main.draw()` at a fixed frame rate (60 FPS). `Main.update()` delegates to `Board`, which first updates the menu, then calls `Board.update()` only when the menu is closed and the game is not over, ensuring a clean separation between menu and gameplay.

### 4.2. Character movement and input

Character movement is handled in `Character.update(max_level)`, where keyboard input is read using `pyxel.btnp`.

- Mario uses up/down arrow keys to change level; Luigi uses W/S.
- Movement is allowed only if the character is not resting and not reprimanded, and the new level stays within 0 and  $\text{max\_level} / 2 - 1$ .

This algorithm ensures simple, discrete vertical movement that matches the conveyor layout.

### 4.3. Package update and handling algorithm

The package update algorithm in `Board.__package_update_all()` iterates over all active Package objects and performs three main steps:

- 1) Synchronize each package's speed with the Conveyor speed at the current level and call `package.update()`.
- 2) If `package.at_the_end()` is true, check:
  - ▶ If it is at the final conveyor: Luigi can load it into the truck; otherwise it breaks.
  - ▶ If it is on an even conveyor: Mario must be at the matching level to pass it; otherwise it breaks.
  - ▶ If it is on an odd conveyor: Luigi must be at the matching level to pass it; otherwise it breaks.
- 3) When a box is handled correctly, increase score and move it to the next conveyor; when it breaks, increase fails and trigger the boss punishment for the responsible character.

Packages in "BROKEN" or "TRUCK" state are removed from the list to keep the system clean.

### 4.4. Truck delivery timing

When `Truck.number_of_packages` reaches a chosen threshold, `Board.__truck_delivery()` is called:

- Score is increased, deliveries counter is updated and the truck is emptied.
- `Truck.start_delivery()` sets the state to "DELIVERY" and remembers the current frame.

- Characters are set to resting = True and their package flags are cleared.

In `Board.update()`, as long as the truck is delivering, the algorithm checks `Truck.delivery_done()`. Once the delivery time passes, `Truck.finish_delivery()` is called and the resting flags are cleared, returning to normal gameplay.

#### 4.5. Boss punishment system

The boss system is a simple state machine controlled by `boss_active`, `boss_target` and `boss_timer` in `Board`:

- On a failure (broken box), if no punishment is currently active, `boss_active` is set to true, `boss_target` is set to “MARIO” or “LUIGI” depending on who failed, and `boss_timer` is initialized to a certain number of frames.
- While `boss_active` is true, `boss_timer` decreases each frame, the corresponding character’s reprimand flag is set and the other one is cleared, and normal gameplay updates (movement and packages) are skipped.
- When `boss_timer` reaches zero, `boss_active` is set to false and both reprimand flags are cleared, allowing the game to continue.

This avoids nested or overlapping punishments and guarantees that every punishment eventually ends.

## 5. Work done and functionality

In here we will explain the features that have been included in the game. We will present it with the same structure and build order according to the sprints we have successfully implemented.

### 5.1. Sprint 1: Objects and graphical interface

- Create a class for each main game element: Characters, Conveyor, Truck, Package, etc.
- All the behavior logic of each entity must be contained in its corresponding class. Avoid including game logic in the main program (penalty if it occurs).
- Design the graphical interface of the scenario: a single screen with the conveyor belts, floors, stairs, and truck.
- Implement a score counter and error counter (failures) visible during the game.
- Define the basic data structures that will manage the state of the conveyor belts, packages in transit, and the difficulty level.

### 5.2. Sprint 2: Mario and Luigi Movement

- Implement the vertical movement control of the characters:
  - Mario: Arrow Up / Arrow Down keys.
  - Luigi: W / S keys.
- Each character must be able to go up and down floors using the stairs, respecting the upper and lower limits.
- Graphically display the current position of each character (Floor0, Floor1, etc.) on the screen.

### 5.3. Sprint 3: Packages movement

- Implement the package flow on the conveyor belts according to the established rules:
  - Conveyor0 generates empty boxes for Mario.
  - Even Conveyors → controlled by Mario.
  - Odd Conveyors → controlled by Luigi.
- Graphical representation of the packages must change according to the belt they are on.
- When a package reaches the end of a conveyor belt:
  - If the corresponding character is on the correct floor, they automatically pick it up and pass it to the next conveyor belt.
  - If not, the package falls and a failure is recorded.
    - (Extra:) change the sprite of Mario or Luigi.
- Implement the automatic movement of packages based on the speed of the current level.

## 5.4. Sprint 4: Scoring system, failures, and end of game

- Implement scoring:
  - +1 point for each package correctly delivered to the next conveyor belt.
  - +10 points for each completed truck (8 packages delivered).
- Manage the failure counter (3 failures = game over).
- Implement the truck logic and character rest:
  - When it receives 8 packages, it goes out for delivery.
  - During delivery, the conveyor belts stop temporarily. If a package is at the last position of the conveyor, it is deleted.
  - Upon return, activity resumes.
- Display a game over message or animation when 3 failures are exceeded.
- Complete Boss's visual effects: he will appear when a package falls, after rest...

## 5.5. Sprint 5: Difficulty levels and final adjustments (optional)

- Incorporate the difficulty levels (Easy, Medium, Extreme, Crazy) according to the rule table:
  - Conveyor belt speed.
  - Minimum number of packages in play.
  - Failure elimination rules for truck delivery.
- Adjust the interface to display the current level.
- Allow changing the level from the menu or before starting the game.
- Add optional sound effects: conveyor belt movement, error sounds, etc.
- Implement high score tables or local competitive mode

## 5.6. Extra functionality

- Incorporate menu for changing difficulty.
- Incorporate welcoming screen/start menu (i.e.: a small drawing of the name of the game and animated text inviting to press ENTER to play).

## 6. User manual

- Starting the game:
  - Launch the Python script that instantiates Main (e.g., python main.py).
  - The game window opens with the default difficulty and the possibility to open the menu.
- Controls:
  - General:
    - Q: quit the game
    - M: open/close the difficulty menu
    - ENTER: confirm the selected difficulty in the menu.
  - Mario/Luigi
    - Arrow UP / W: move character up.
    - Arrow DOWN / S: move character down.

## 7. Conclusions

### 7.1. Final summary

The project successfully delivers a small but complete 2D game inspired by the Mario Bros. Game & Watch factory game, implemented in Python using Pyxel.

It demonstrates object-oriented design with classes for the main game controller, characters, conveyors, packages and truck, as well as the use of a simple configuration module for sprites and constants.

### 7.2. Main problems encountered

Several issues related to game states were encountered, including freezes when the boss or the truck entered special modes and the main loop stopped updating the logic needed to exit those modes.

Additional problems appeared with repeated boss activation during consecutive fails, incorrect character movement while being reprimanded, and overly restrictive package spawn conditions that could leave the game with no new boxes.

The package logic was the hardest part to implement in the game, anyway implementing the individual features wasn't hard, combining them to work properly was the hard part of the project.

### 7.3. Personal evaluation and improvements

This project was a fun introduction to OOP and quite a challenge. Nevertheless we enjoyed the process of problem-solving and coming up with fixes and features.

If the project were extended, priority improvements would include adding richer animations for characters and boss, a persistent high-score system with local storage, and a more adaptive difficulty that reacts to the player's performance.

### 7.4. Issues and solutions

Several typical state-management issues appeared during development, such as the game "freezing" when the boss or truck entered a special state and the main loop stopped updating the logic that should exit that state.

This was solved by centralizing state control inside `Board.update`, avoiding extra conditions in `Main.update`, and by using clear boolean flags (`boss_active`, `delivering`, `resting`, `reprimand`) plus timers to ensure that every special state always has a defined exit.

Another frequent issue was repeated boss activation when multiple boxes failed in a row; this was fixed by wrapping boss activation in `if not self.boss_active` so a new reprimand cannot start until the previous one has finished.

Finally, the package spawn logic was adjusted to avoid ending up with no boxes after a series of fails, temporarily simplifying the spawn condition while debugging the boss and truck systems.