1 Introduction

Galaxy is a Haskell program which simulates celestial movement and, if time permits, visualizes the galaxy system with OpenGL. The visualization of the galaxy should be dynamic which represent the the whole program assuming the universe is a 2-D plane.

2 Model

2.1 Simplification

1. Galaxy assumes that the galaxy we simulate is an isolated system which is not affected by any other system.

2. Instead of 3-D which is the real world situation, Galaxy simulates 2-D world.

3. There are only two kinds of celestial body: star and planet.

4. All celestial bodies are considered as mass points which means Galaxy doesn’t worry about collision between celestial bodies.

5. Gravitational constant $G$ is equal to $6.67 \times 10^{-11}$.

2.2 Celestial Body

Celestial body has the following properties:

1. Coordinate: (float, float)

2. Mass: float

3. Velocity: (float, float)
2.3 Gravity

The equation of gravity is

\[ F = G \frac{m_1 m_2}{r^2} \]

In galaxy, it computes \( F_x \) and \( F_y \) separately:

\[ F_x = G \frac{m_1 m_2}{(x_1 - x_2)^2} \]
\[ F_y = G \frac{m_1 m_2}{(y_1 - y_2)^2} \]

Because force is a vector, we define that for body 1, \( F_x < 0 \) if \( x_2 < x_1 \) and \( F_x > 0 \) otherwise. The same for \( F_y \).

2.4 Acceleration

We use Newton’s second law to calculate acceleration:

\[ F = ma \]

Then we can have acceleration in different dimension:

\[ a_x = \frac{F_x}{m} \]
\[ a_y = \frac{F_y}{m} \]

Because acceleration is a vector, we define that \( a_x \) has the same sign as \( F_x \).

2.5 Velocity

Let \( \Delta t \) denote the smallest time interval defined by user or default. The velocity of body in galaxy should change as

\[ v'_x = v_x + a_x \Delta t \]
\[ v'_y = v_y + a_y \Delta t \]

3 Visualization

The result of visualization should be dynamic. After a certain time interval, the graph of current state of galaxy should update. It should show every existing celestial body as dot.