Labo Parallelle

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1 Varianten v/h programma

1.1 CPU

Het berekenen van de positie en snelheid gebeurd op basis van 2 geneste for-loops. Het nadeel hiervan is dat elke berekening serieel gebeurd waardoor de snelheid lager is.

```
for (int i = 0; i < length; ++i)
  {
      for (int j = 0; j < length; ++j)
      {

          if (i == j)
              continue;

          cl_float3 pos_a = host_pos[i];
          cl_float3 pos_b = host_pos[j];

          float dist_x = (pos_a.s[0] - pos_b.s[0]) * distance_to_nearest_star;
          float dist_y = (pos_a.s[1] - pos_b.s[1]) * distance_to_nearest_star;
          float dist_z = (pos_a.s[2] - pos_b.s[2]) * distance_to_nearest_star;


          float distance = sqrt(
                  dist_x * dist_x +
                  dist_y * dist_y +
                  dist_z * dist_z);

          float force_x = -mass_grav * dist_x / (distance * distance * distance);
          float force_y = -mass_grav * dist_y / (distance * distance * distance);
          float force_z = -mass_grav * dist_z / (distance * distance * distance);

          float acc_x = force_x / mass_of_sun;
          float acc_y = force_y / mass_of_sun;
          float acc_z = force_z / mass_of_sun;

          host_speed[i].s[0] += acc_x * delta_time;
```

```
            host_speed[i].s[1] += acc_y * delta_time;
            host_speed[i].s[2] += acc_z * delta_time;



        }
    }

```

1.2 V1: parallellisatie (kernel.cl)

Hierbij hebben we de buitenste for-loop geparallelliseerd. In de kernel file staat de integer i gedefinieerd die steeds automatisch zal incrementeren telkens wanneer de kernel wordt opgeroepen. De GPU kan meerdere threads tegelijk berekenen. Bij meerdere threads zal er een aanzienlijk snelheidsverschil te merken zijn.

```
    if(i>=length) {
    return;
  }

    for (int j = 0; j < length; ++j)
        {
            if (i == j)
                continue;

            float3 pos_a = host_pos[i];
            float3 pos_b = host_pos[j];

            float dist_x = (pos_a.s0 - pos_b.s0) * distance_to_nearest_star;
            float dist_y = (pos_a.s1 - pos_b.s1) * distance_to_nearest_star;
            float dist_z = (pos_a.s2 - pos_b.s2) * distance_to_nearest_star;


            float distance = sqrt(
                    dist_x * dist_x +
                    dist_y * dist_y +
                    dist_z * dist_z);

            float force_x = -mass_grav * dist_x / (distance * distance * distance);
            float force_y = -mass_grav * dist_y / (distance * distance * distance);
            float force_z = -mass_grav * dist_z / (distance * distance * distance);

            float acc_x = force_x / mass_of_sun;
            float acc_y = force_y / mass_of_sun;
            float acc_z = force_z / mass_of_sun;

            host_speed[i].s0 += acc_x * delta_time;
            host_speed[i].s1 += acc_y * delta_time;
            host_speed[i].s2 += acc_z * delta_time;



        }
```

```

        host_pos[i].s0 += (host_speed[i].s0 * delta_time) / distance_to_nearest_star;
        host_pos[i].s1 += (host_speed[i].s1 * delta_time) / distance_to_nearest_star;
        host_pos[i].s2 += (host_speed[i].s2 * delta_time) / distance_to_nearest_star;

}

```

1.3 V2: Atomische operaties toevoegen (kernel2.cl)

In deze code maken we gebruik van de functie `atomic_add()`. Met de CPU moeten de standaard Read,Modify en Write operaties uitgevoerd worden. Met de `atomic_add()` functie maak je gebruik van speciale hardware die de GPU heeft ingebouwd. Hierdoor verzekeren we dat steeds 1 thread RMW uitvoert zodat er geen fouten ontstaan.

```
    typedef union
{
  float3 vec;
  float arr[3];
} float3_;

__kernel void simulate_gravity( __global float3 *host_pos, __global float3_ *host_speed, const int length)
{
  const int i = get_global_id(0);

  const float delta_time = 1.f;
     // const float grav_constant = 6.67428e-11;
      const float grav_constant = 1;
      const float mass_of_sun = 2;
      const float mass_grav = grav_constant * mass_of_sun * mass_of_sun;
      const float distance_to_nearest_star = 50;


  if(i>=length) {
    return;
  }

    for (int j = 0; j < length; ++j)
        {
            if (i == j)
                continue;

            float3 pos_a = host_pos[i];
            float3 pos_b = host_pos[j];

            float dist_x = (pos_a.s0 - pos_b.s0) * distance_to_nearest_star;
            float dist_y = (pos_a.s1 - pos_b.s1) * distance_to_nearest_star;
            float dist_z = (pos_a.s2 - pos_b.s2) * distance_to_nearest_star;


            float distance = sqrt(
                dist_x * dist_x +
```

```
                    dist_y * dist_y +
                    dist_z * dist_z);

            float force_x = -mass_grav * dist_x / (distance * distance * distance);
            float force_y = -mass_grav * dist_y / (distance * distance * distance);
            float force_z = -mass_grav * dist_z / (distance * distance * distance);

            float acc_x = force_x / mass_of_sun;
            float acc_y = force_y / mass_of_sun;
            float acc_z = force_z / mass_of_sun;

           // host_speed[i].s0 += acc_x * delta_time;
           // host_speed[i].s1 += acc_y * delta_time;
           // host_speed[i].s2 += acc_z * delta_time;

      AtomicAdd(&host_speed[i].arr[0], (float)(acc_x * delta_time));
        AtomicAdd(&host_speed[i].arr[1], (float)acc_y * delta_time);
        AtomicAdd(&host_speed[i].arr[2], (float)acc_z * delta_time);



        }

          host_pos[i].s0 += (host_speed[i].vec.s0* delta_time) / distance_to_nearest_star;
          host_pos[i].s1 += (host_speed[i].vec.s1  * delta_time) / distance_to_nearest_star;
          host_pos[i].s2 += (host_speed[i].vec.s2  * delta_time) / distance_to_nearest_star;

}

```

2 Vergelijking

In de tabel weergegeven in figuur 2 ziet u de resultaten van onze metingen. Deze resultaten hebben we ook gevisualiseerd in een grafiek. Hier ziet u heel duidelijk dat hoe meer punter er berekend moeten worden, hoe groter het belang van parallellisatie is.

Figuur 1: Resultaten

	V1	CPU	V2
10	0,153335	0,148368	0,143848
100	0,147805	0,149218	1,151004
1000	0,143767	0,303834	0,151156
10000	0,35235	22,948522	1,823096

Figuur 2: Grafiek