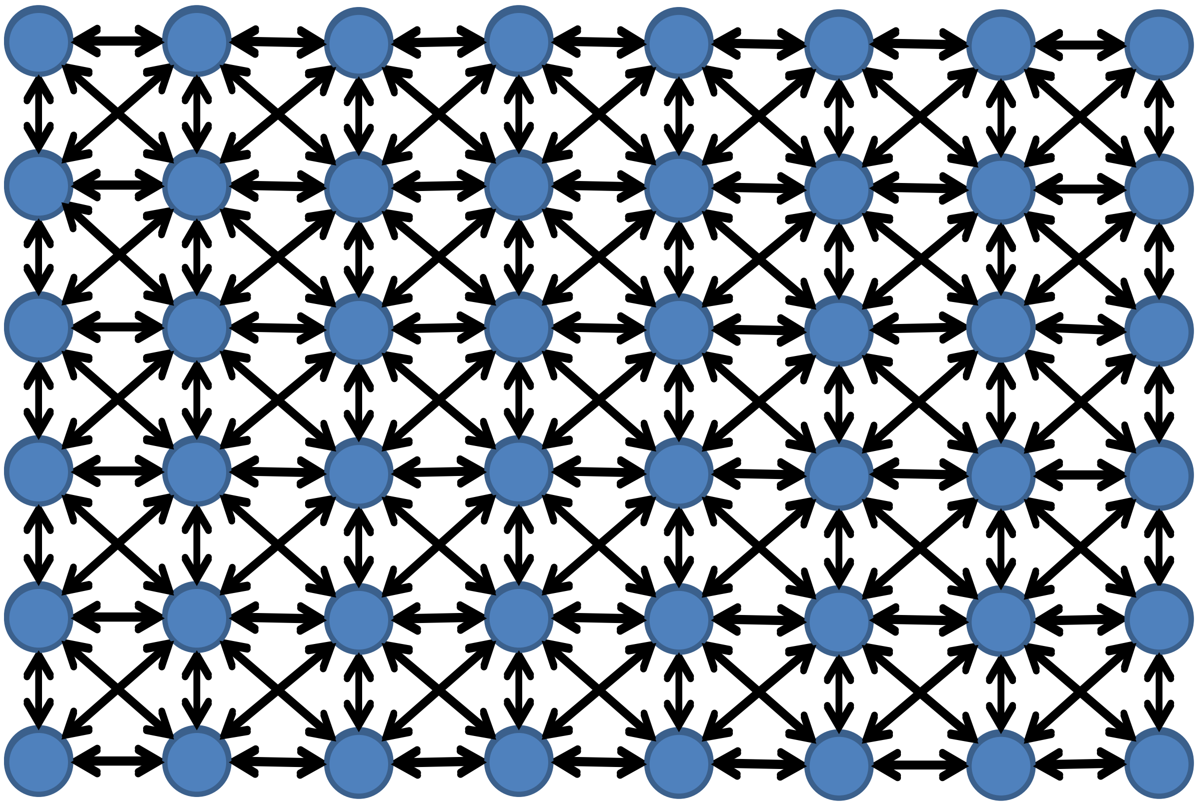
The Mass Spring Model

CS-116B: Computer Graphics Algorithms
Spring 2018

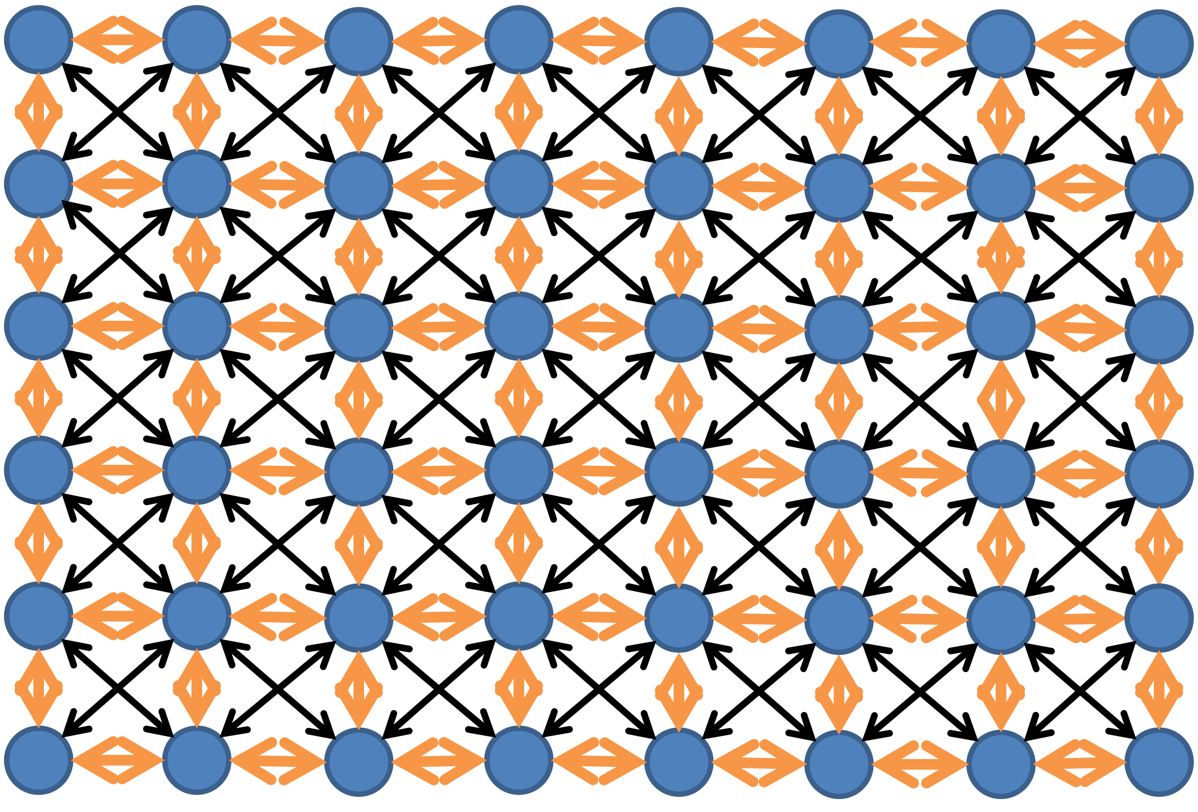
Mass spring model: anatomy

Our cloth is comprised of an array of particles interconnected via weightless springs:



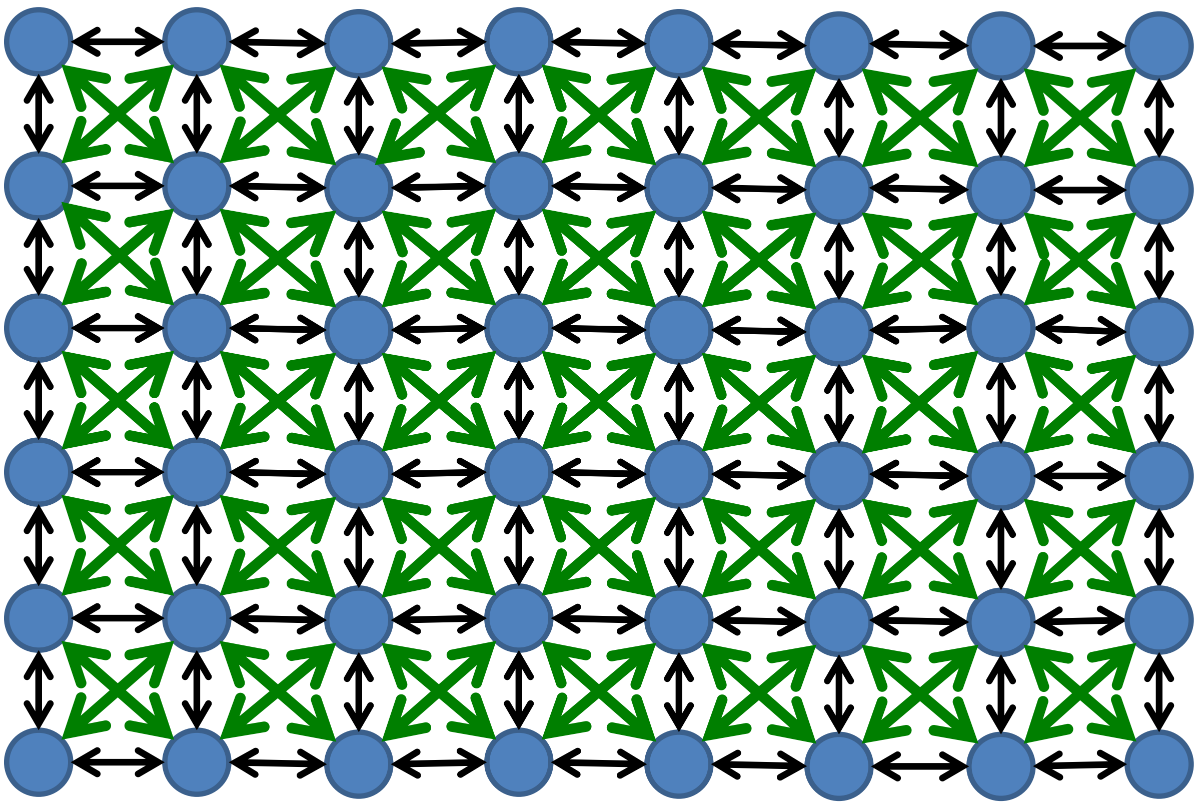
Mass spring model: anatomy

Orange colored arrows represent the **structural springs**:



Mass spring model: anatomy

Green colored arrows represent the **shear springs**:



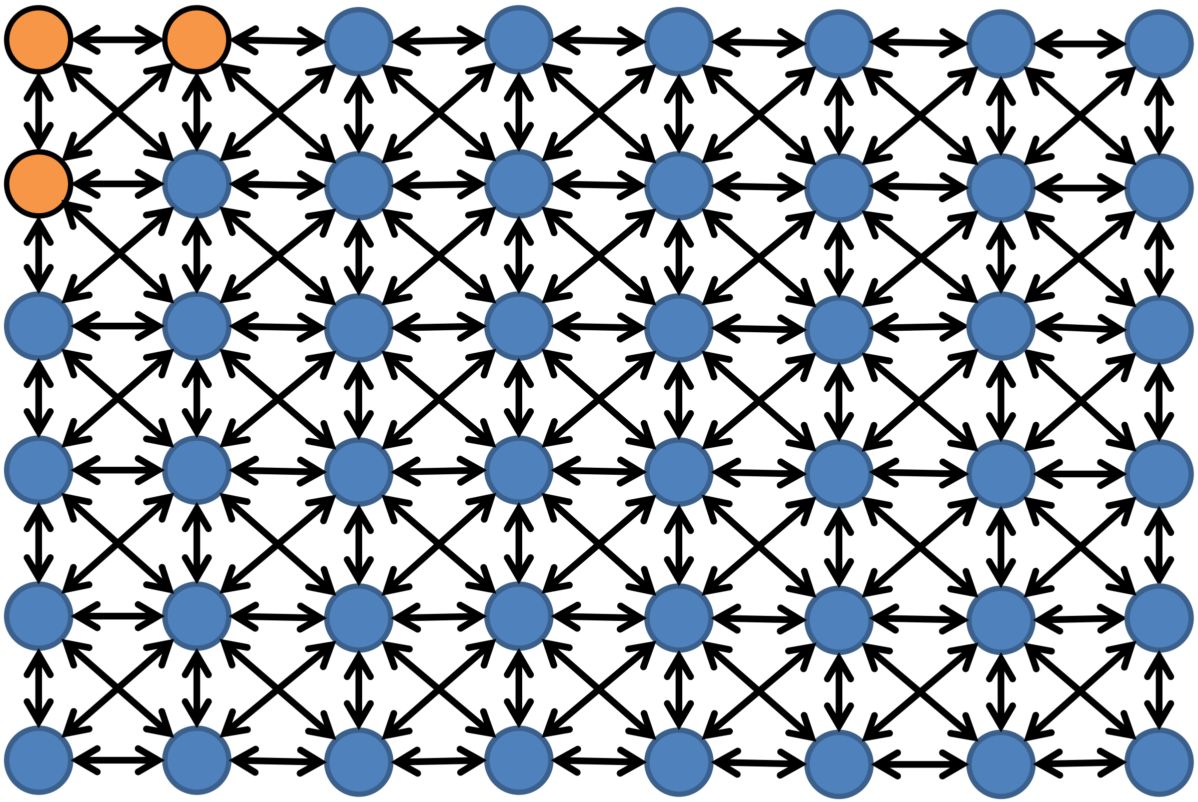
Computing surface normals

Why compute surface normals?

- To calculate wind forces pushing against the cloth.
- To calculate gravitational forces pulling the cloth.
- To calculate collision detection with solid objects.

Computing surface normals

Choose three adjacent particles that form a triangle:



Compute surface normals

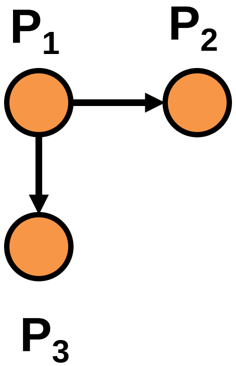
Compute the normal vector of the triangle defined by the position of the particles p_1, p_2, and p_3:

Vector $v_1 = (P_2 - P_1)x + (P_2 - P_1)y + (P_2 - P_1)z$

Vector $v_2 = (P_3 - P_1)x + (P_3 - P_1)y + (P_3 - P_1)z$

cross product of v_1 and $v_2 = v_1 \times v_2$

Normalized $v_1 \times v_2 = (v_1 \times v_2)$ / (magnitude of $v_1 \times v_2$)



Computing surface normals

- Wind forces act on planes of the cloth
- A plane is formed from three particles in a triangular pattern.
- The normal of the plane is then used to compute how much wind forces act on the cloth at the particular plane.
- The wind force is a vector. It has values in
  - X direction
  - Y direction
  - Z direction
- Gravity is a force too but it has only has values in Y direction. (Y is down).

Compute surface normals

```
vec3 compute_triangle_normal (particle_node *p1,
particle_node *p2, particle_node *p3)
{
  vec3 v1, v2;

  v1.x = p2->pos.x - p1->pos.x;
  v1.y = p2->pos.y - p1->pos.y;
  v1.z = p2->pos.z - p1->pos.z;
  v2.x = p3->pos.x - p1->pos.x;
  v2.y = p3->pos.y - p1->pos.y;
  v2.z = p3->pos.z - p1->pos.z;
  return compute_cross_product (v1, v2);
}
```

Compute wind force

- The wind force is a force vector.
- To compute how much wind force moves the three particles forming a plane:
  - Compute the dot product between the wind force (a vector) and the normalized cross product of the three particles (a vector).
- Apply the dot product (computed above) as a force to each of the three particles (P_1, P_2, P_3) that make up the plane. This will affect how each of the three particles is then displaced by the wind force.

Cloth optimization trick

For a stiffer cloth you could increase the “k” value of the spring or add a set of “flexion springs” between (i,j) and (i+2,j) and (i,j+2) and (i,j+2). Where (i,j) represent the row and column of each particle.