Multimedia and computer animation

Exercise - Cloth simulation

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From the lecture…

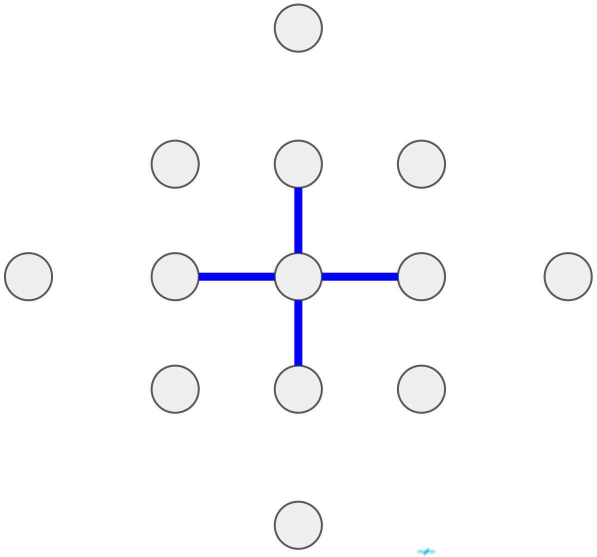
- Cloth simulation variants
  - Diskrete
    - Grid of mass points
    - Points are connected i.e. by springs
  - Continuous
    - Using curves
  - Particle based
    - Similar to the discrete variant

From the lecture…

- Xavier Provot - Deformation constraints in a mass-spring model
    - Cloth is divided into discrete parts
        - Points of mass
        - Springs
    - Simple algorithm
        - For each mass point
            - Add forces acting on the point as a result of all connected springs
            - Apply the resulting force to the point

Types of spring

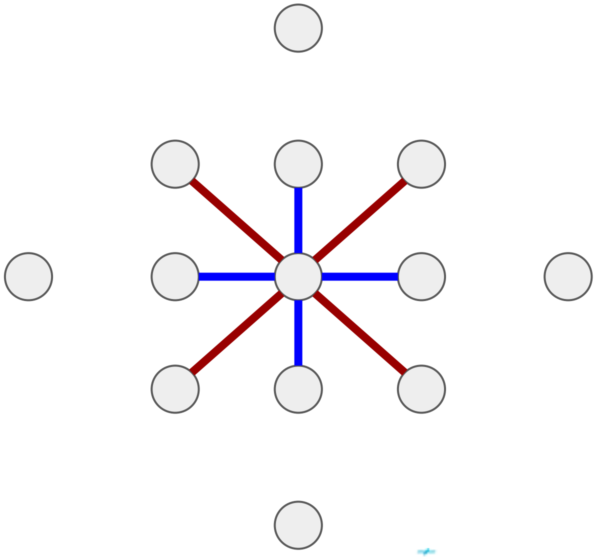
- Structural
  - Covers forces of…
    - Compression
    - Stretching



Source: X. Provot, Deformation Contraints in a Mass-Spring Model to Describe Rigid Cloth Behavior Proceedings of Graphics Interface, 1995
(https://graphicsinterface.org/wp-content/uploads/gi1995-17.pdf)

Types of spring

- Structural
  - Covers forces of…
    - Compression
    - Stretching
- Shear
  - Covers…
    - Shearing forces



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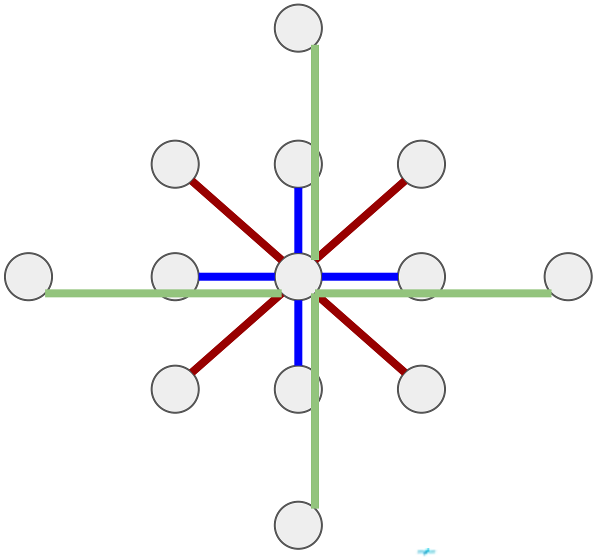
Types of spring

- Structural
  - Compression
  - Stretching
- Shear
  - Shear forces - movement to the side
- Flex / Bend
  - Forces acting on the cloth when bending or flexing



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Forces of a spring

- Elasticity
  - Spring wants to return to its original (rest) length:

$$K_{i,j,k,l}\left[\mathbf{l}_{i,j,k,l} - l^0_{i,j,k,l}\frac{\mathbf{l}_{i,j,k,l}}{|\mathbf{l}_{i,j,k,l}|}\right]$$

$K_{i,j,k,l}$ - Coefficient of elasticity

$\mathbf{l}_{i,j,k,l}$ - Vector for points (i,j) -> (k,l)

$l^0_{i,j,k,l}$ - Rest length of a spring

$C_{dis},\ C_{damp}$ - Damping coefficient

$\mathbf{x}_{i,j}$ - Position of point (i,j)

$\mathbf{v}_{i,j}$ - Velocity of point (i,j)

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- Damping
  - Can be implemented as viscosity (an external force):

$$-C_{dis}\mathbf{v}_{i,j}$$

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- Damping
  - Can be implemented as viscosity (an external force):

$$-C_{dis}\mathbf{v}_{i,j}$$

  - Or by damping the spring force internally:

$$C_{damp}\frac{(\mathbf{v}_{k,l} - \mathbf{v}_{i,j}) \cdot (\mathbf{x}_{k,l} - \mathbf{x}_{i,j})}{|\mathbf{x}_{k,l} - \mathbf{x}_{i,j}|}\frac{(\mathbf{x}_{k,l} - \mathbf{x}_{i,j})}{|\mathbf{x}_{k,l} - \mathbf{x}_{i,j}|}$$

$K_{i,j,k,l}$	-	Coefficient of elasticity
$\mathbf{l}_{i,j,k,l}$	-	Vector for points (i,j) -> (k,l)
$l^0_{i,j,k,l}$	-	Rest length of a spring
C_{dis}, C_{damp}	-	Damping coefficient
$\mathbf{x}_{i,j}$	-	Position of point (i,j)
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Cloth simulation

Task - implement spring force computation

- ClothSpring.cpp
  - GetActingForce()
    - Include:
      - Damping
      - Elasticity
  - AddForceToNodes()
    - Add a symmetric force acting on both particles in a pair

Cloth simulation

Task - implement spring force computation

- ClothSpring.cpp
  - GetActingForce()
    - Include:
      - Damping
      - Elasticity
  - AddForceToNodes()
    - Add a symmetric force acting on both particles in a pair
- You will need to…
  - Get the rest length of a spring
  - Compute the elastic force of the spring based on the real and rest length
  - Compute the damping force of the spring
  - Add the forces and return the result

Super-elasticity

- Cloth stretches too much - unrealistic
- Real cloth loses elasticity when stretched to its limit (elasticity is not a constant parameter of a spring)
- Possible solution: limit the maximum deformation of a spring
  - After moving mass points to their new positions
  - Compute the deformation factor of each spring
    - If above critical value, move both (or the one that is not fixed) in the direction of the spring to return the deformation factor back to the critical value
- See: **X. PROVOT: Deformation Constraints in a Mass Spring Model to Describe Rigid Cloth Behavior** https://graphicsinterface.org/wp-content/uploads/gi1995-17.pdf

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