# Tensegrities

6.885
L4.2
Sept. 20, 2004

- tensegrity = tens(ional int)egrity [Buckminster Fuller] [&Snelson]
  PROJECT: tensegrity sculpture
- abstractly:
  tensegrity = linkage but where each edge is either:
  - bar (as before): fixed length
  - cable: length can only decrease (string/rubber band)
  - strut: length can only increase

- rigidity, etc. make sense here too (semialgebraic)
- infinitesimal rigidity: new constraints on infinitesimal motion $d$:
  - $(C(v)-C(w)) \cdot (d(v)-d(w)) = 0$ for bars $\{v,w\}$
  - $(C(v)-C(w)) \cdot (d(v)-d(w)) \leq 0$ for cables $\{v,w\}$
  - $(C(v)-C(w)) \cdot (d(v)-d(w)) \geq 0$ for struts $\{v,w\}$

  → checkable in polynomial time via linear programming

**Stress:** assignment $s: E \to \mathbb{R}$ of real numbers to edges such that

$$\underbrace{\sum_w s(\{v,w\}) \cdot (C(v)-C(w)) = 0}_{\text{equilibrium}} \quad \text{for all } v \in V.$$

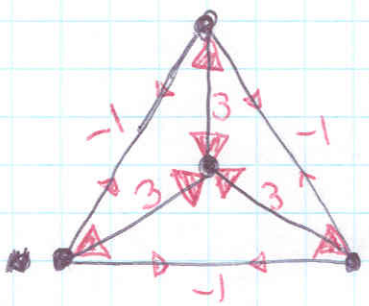
& $s(\{v,w\}) \leq 0$ for struts $\{v,w\}$
& $s(\{v,w\}) \geq 0$ for cables $\{v,w\}$

(bars unconstrained)

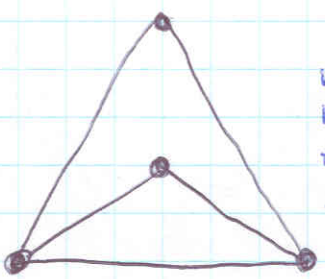
- view $s(\{v,w\})$ as scale factor on force along edge $\{v,w\}$ felt equally by $v$ & $w$.
  - $s(\{v,w\}) > 0 \Rightarrow$ push on $v$ & $w$
  - $s(\{v,w\}) < 0 \Rightarrow$ pull on $v$ & $w$
  - $s(\{v,w\}) = 0 \Rightarrow$ no force.

- trivial equilibrium stress: $s(e) = 0$ for all $e \in E$

e.g.:




equilibrium stress



no nontrivial equilibrium stress