Computergrafik SS 2008

Oliver Vornberger

Kapitel 25:
Animation

Animation

Key Frame Animation

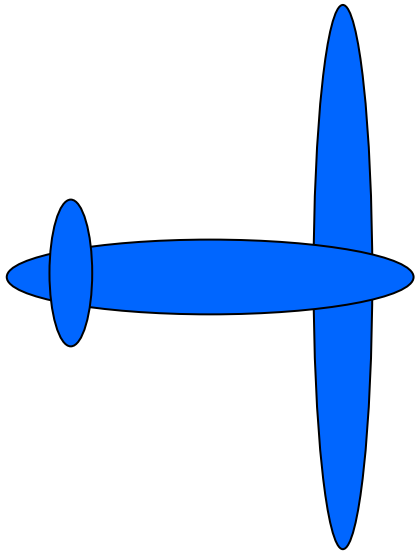
Forward Kinematics

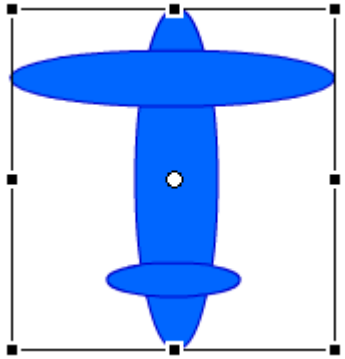
Inverse Kinematics

Particle Systems

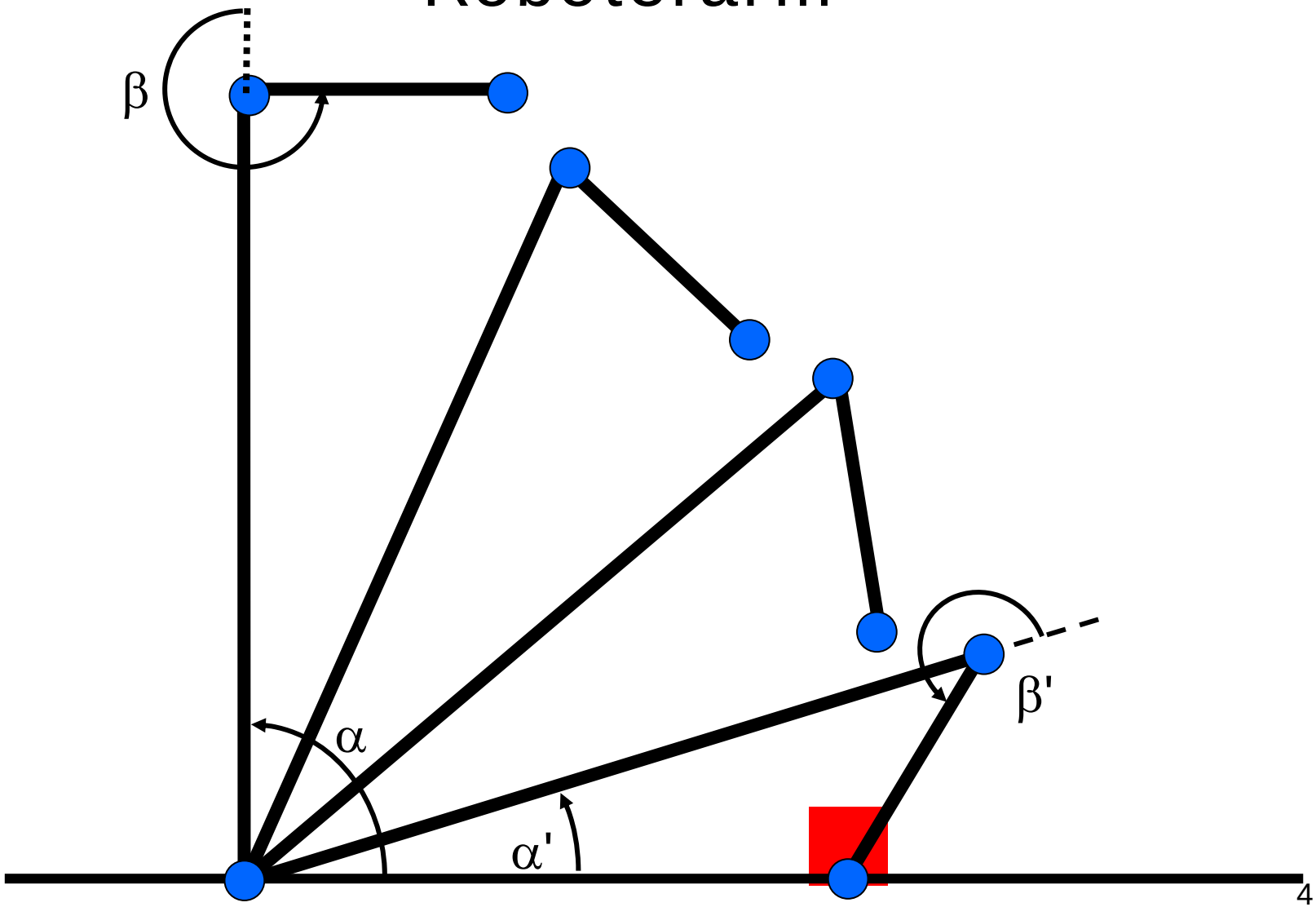
Verhaltensanimation

Key frame Animation

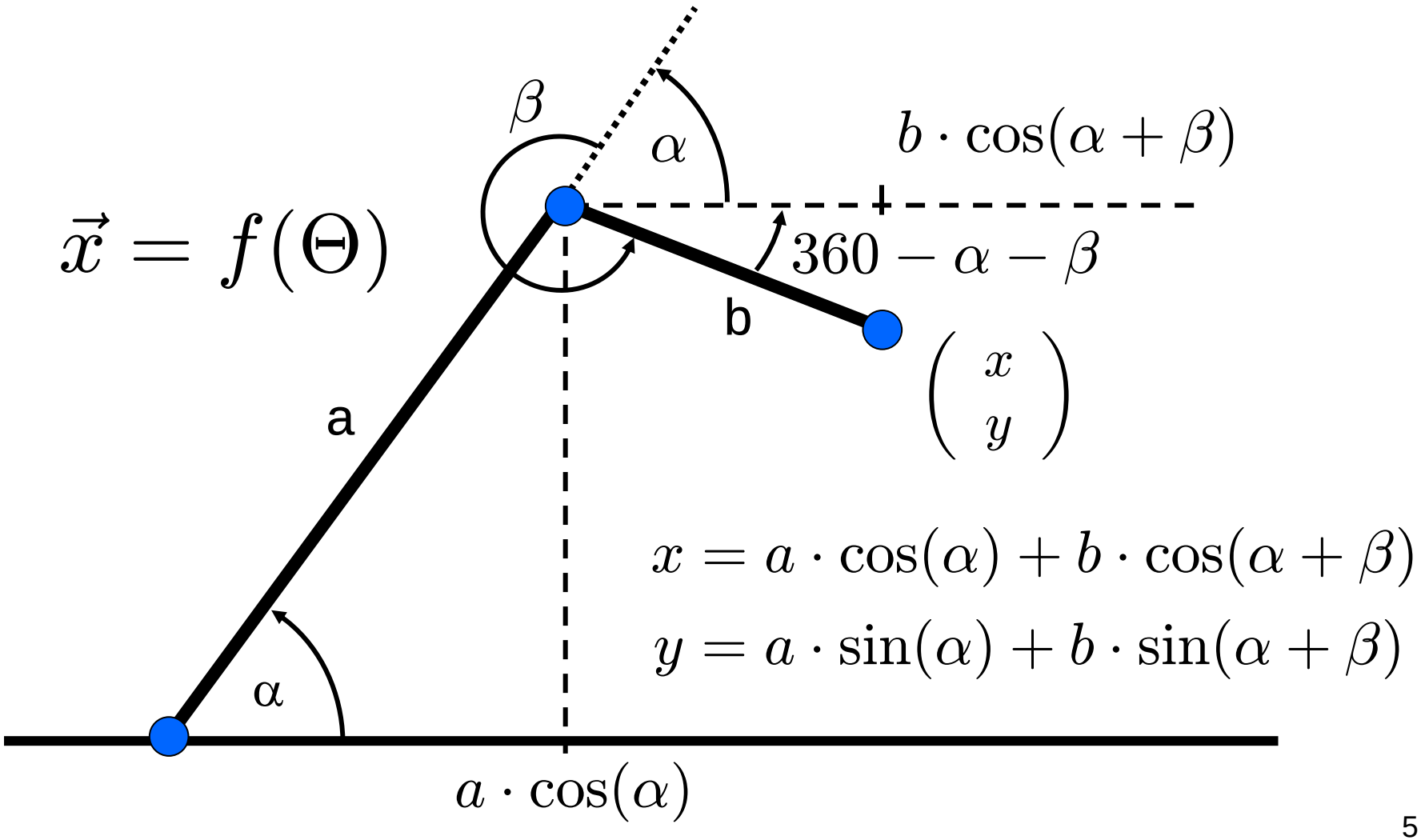




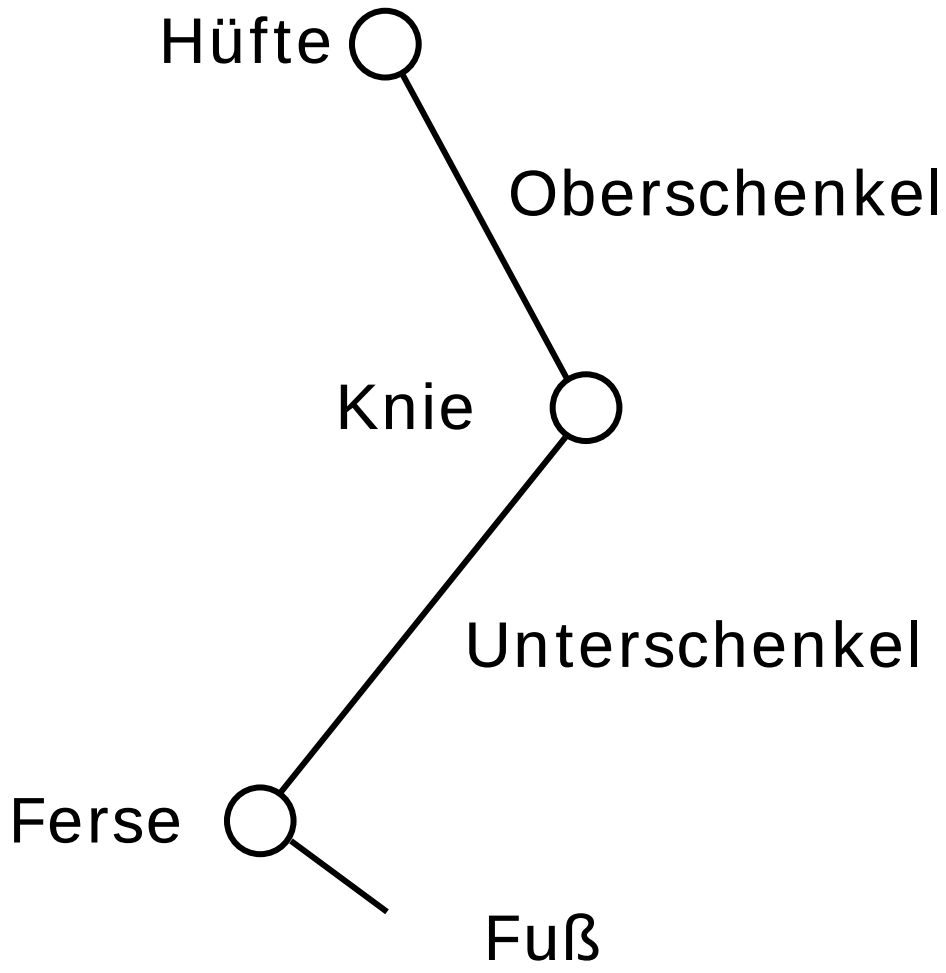
Roboterarm



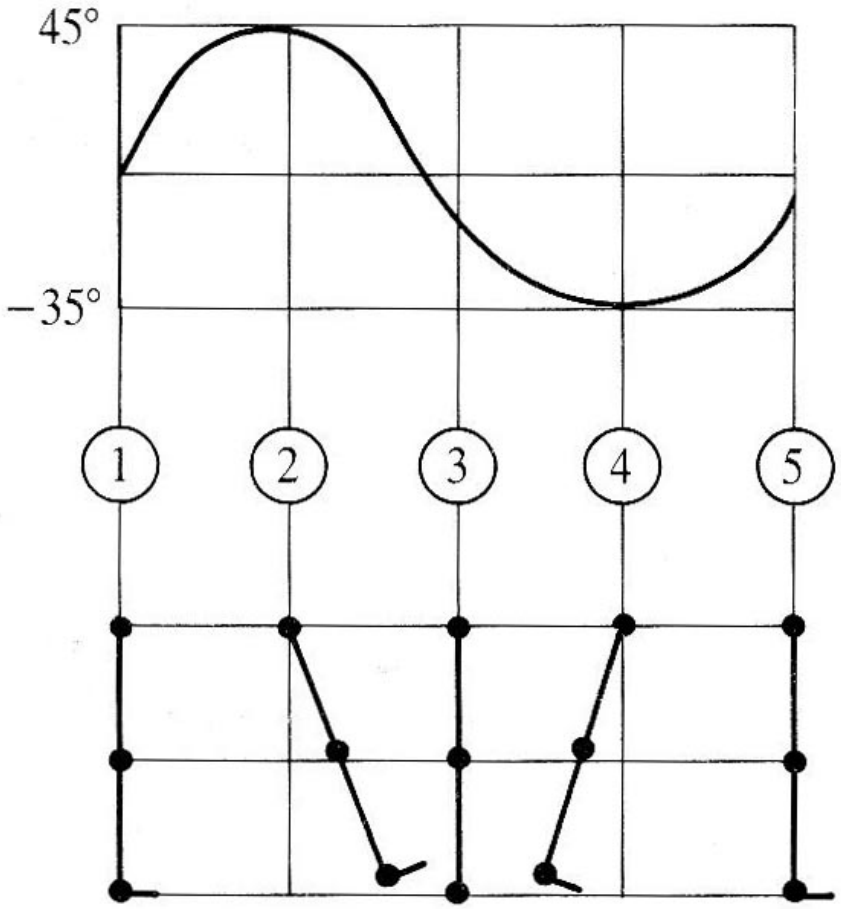
Forward Kinematics



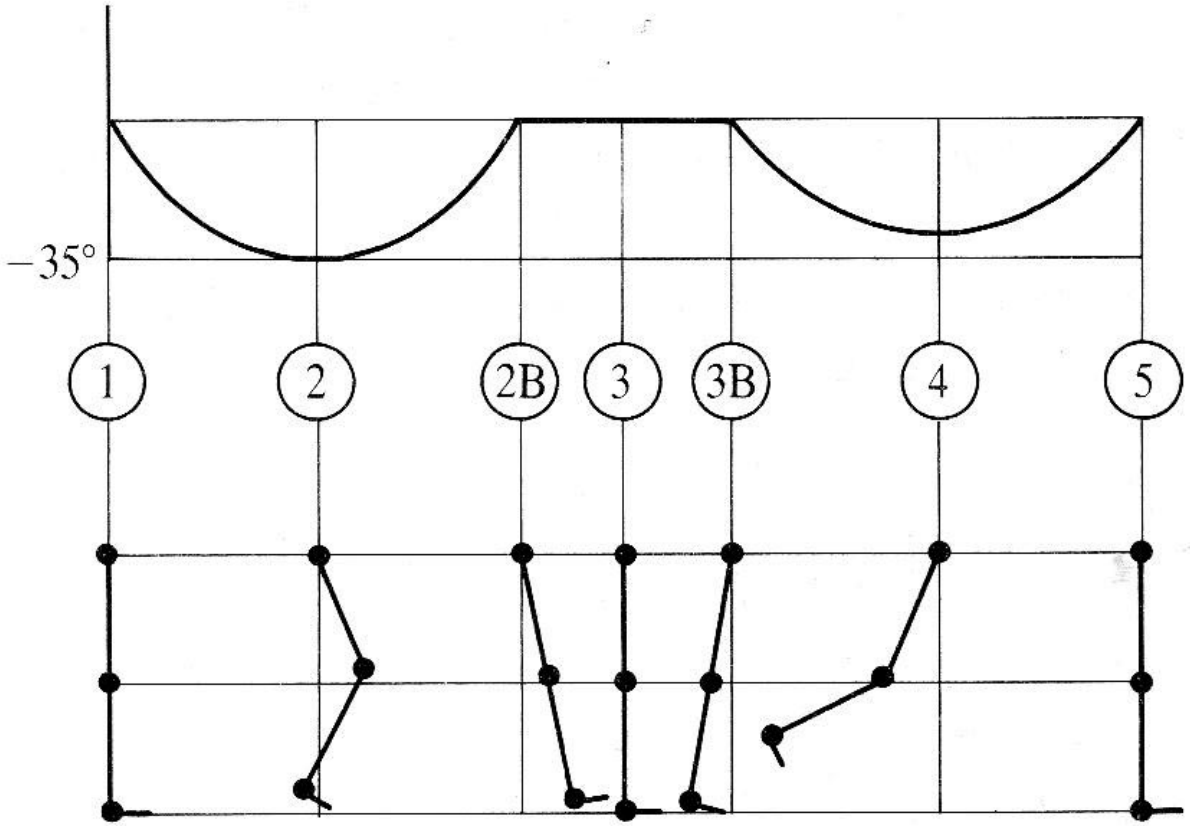
Skript für Forward Kinematics



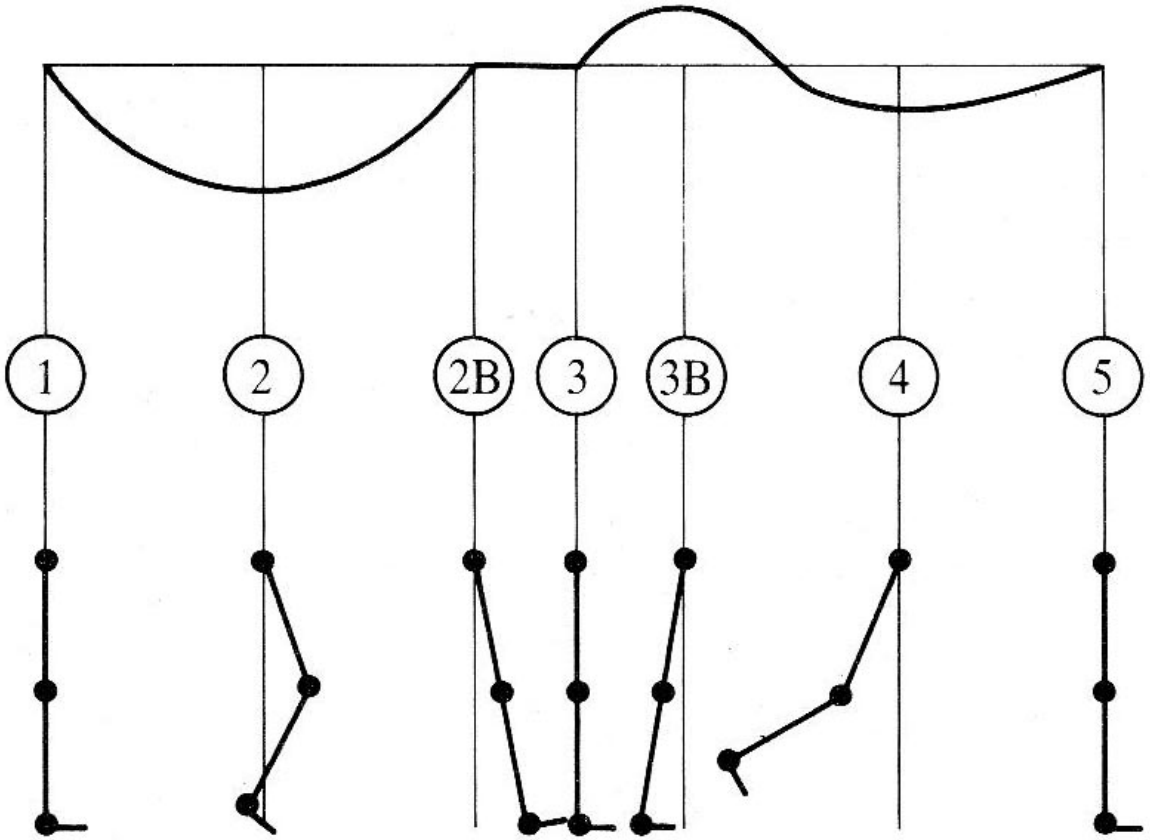
Rotation in der Hüfte



Rotation im Knie



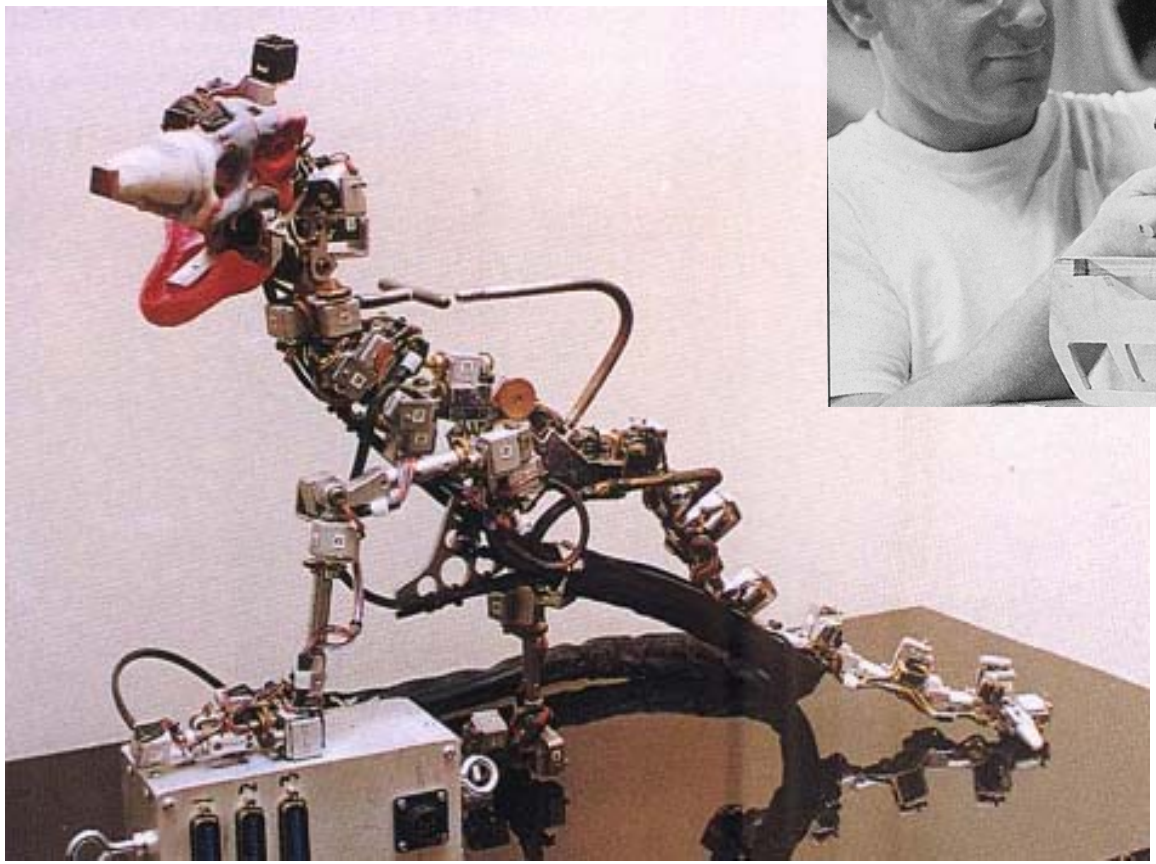
Rotation in der Ferse

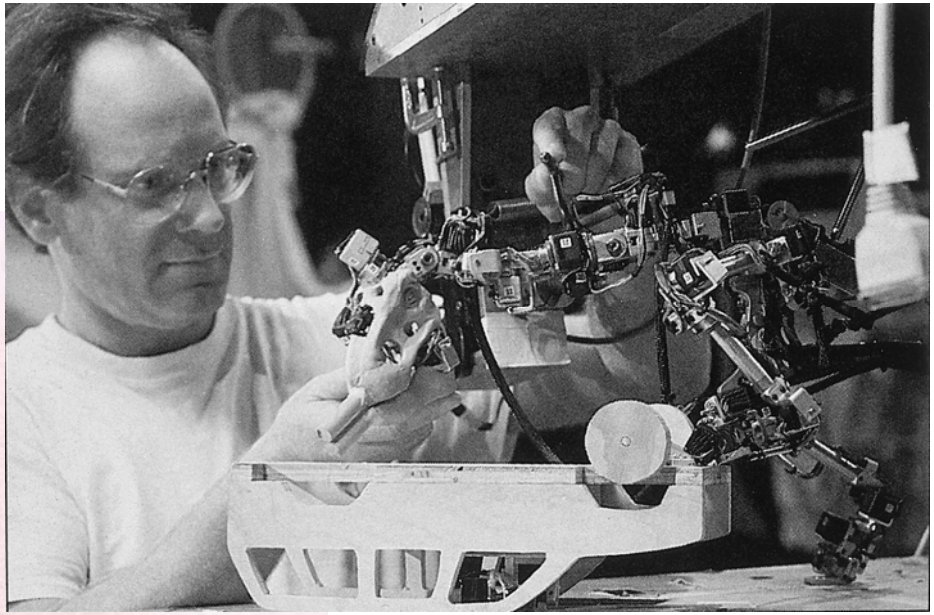


Jurassic Park

geplant als Stop Motion Film

Jurassic Park





R. Magid: "After Jurassic Park", American Cinematographer, December 1993.
Abgedruckt in: Alan Watt "3D-Computergrafik", S. 549, Pearson Studium, ein Imprint von Pearson Education Deutschland GmbH, 2001.

realisiert mit Dinosaur Input Device (DID)

Inverse Kinematics

$$\Theta = f^{-1}(\vec{x})$$

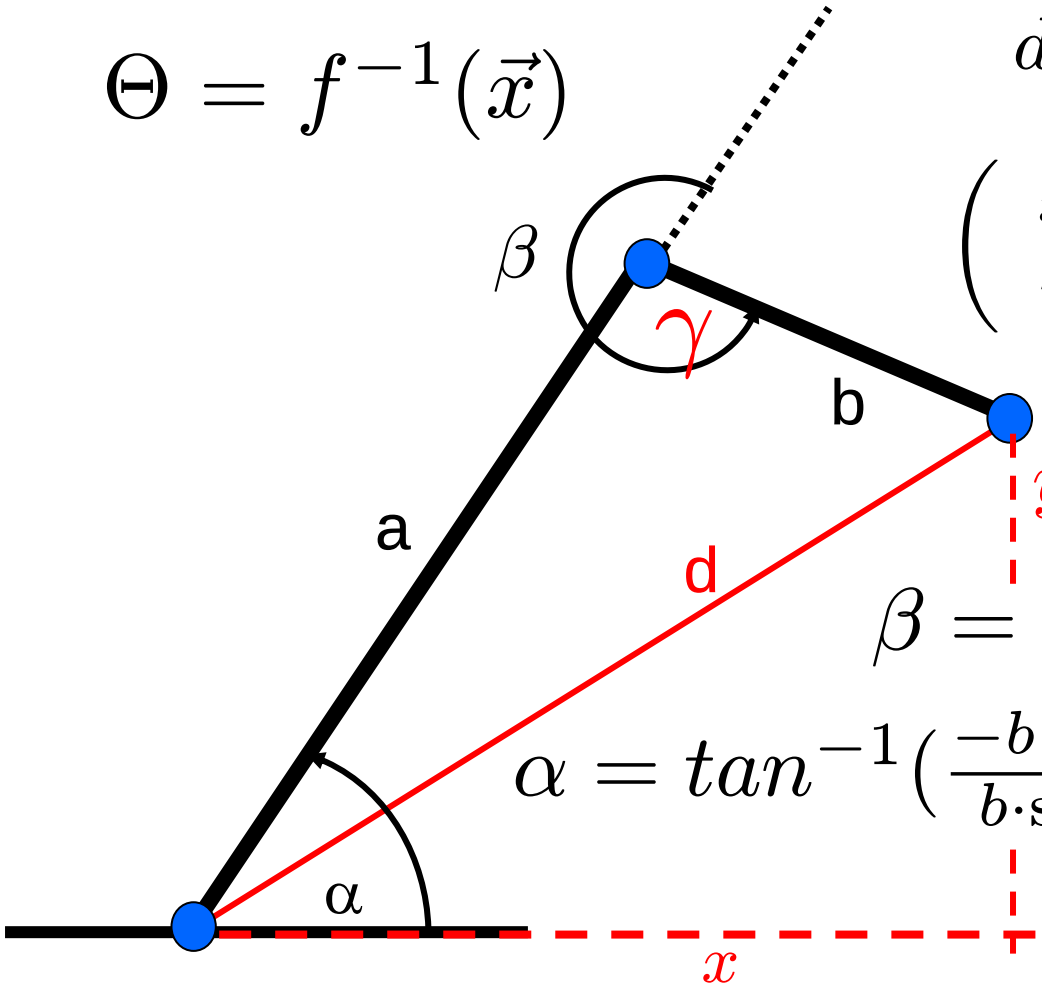
$$d^2 = a^2 + b^2 - 2ab\cos(\gamma)$$

$$\begin{pmatrix} x \\ y \end{pmatrix} \qquad d^2 = x^2 + y^2$$

$$\cos(\gamma) = \frac{a^2+b^2-x^2-y^2}{2ab}$$

$$\beta = \cos^{-1}\left(\frac{x^2+y^2-a^2-b^2}{2 \cdot a \cdot b}\right)$$

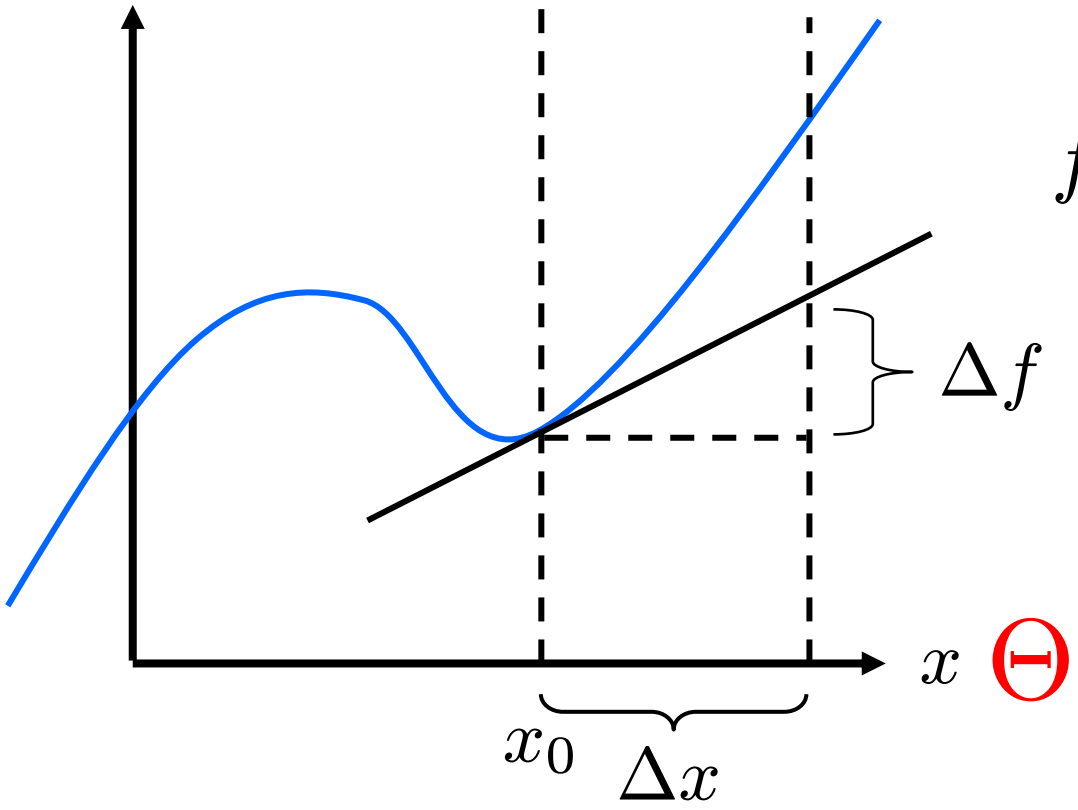
$$\alpha = tan^{-1}\left(\frac{-b \cdot \sin(\beta) \cdot x + (a + b \cdot \cos(\beta)) \cdot y}{b \cdot \sin(\beta) \cdot y + (a + b \cdot \cos(\beta)) \cdot x}\right)$$



Differenzierbarkeit

$\vec{x} = f(\Theta)$

$y = f(x)$



$$f\prime(x_0) \approx \frac{\Delta f}{\Delta x}$$

$$f\prime(x_0) \cdot \Delta x \approx \Delta f$$

$$\Delta x \approx \frac{\Delta f}{f\prime(x_0)}$$

Jakobi-Matrix

Die Jakobi-Matrix einer differenzierbaren Abbildung

$$f : \mathbb{R}^n \to \mathbb{R}^m$$

ist die $m \times n$ Matrix aller partiellen Ableitungen

$$J_f = \frac{\partial f}{\partial x} = \begin{pmatrix} \frac{\partial f_1}{\partial x_1} & \frac{\partial f_1}{\partial x_2} & \dots & \frac{\partial f_1}{\partial x_n} \\ \frac{\partial f_2}{\partial x_1} & \frac{\partial f_2}{\partial x_2} & \dots & \frac{\partial f_2}{\partial x_n} \\ \dots & \dots & & \dots \\ \frac{\partial f_m}{\partial x_1} & \frac{\partial f_m}{\partial x_2} & \dots & \frac{\partial f_m}{\partial x_n} \end{pmatrix}$$

Abhängigkeit zwischen dx und dΘ

Problem: $\Theta = f^{-1}(\vec{x})$

Aber: kleine Änderungen im Winkel verursachen kleine Änderungen in der Position

$$J(\Theta) = \frac{\partial \vec{x}}{\partial \Theta}$$

$$J(\Theta)\partial\Theta = \partial\vec{x}$$

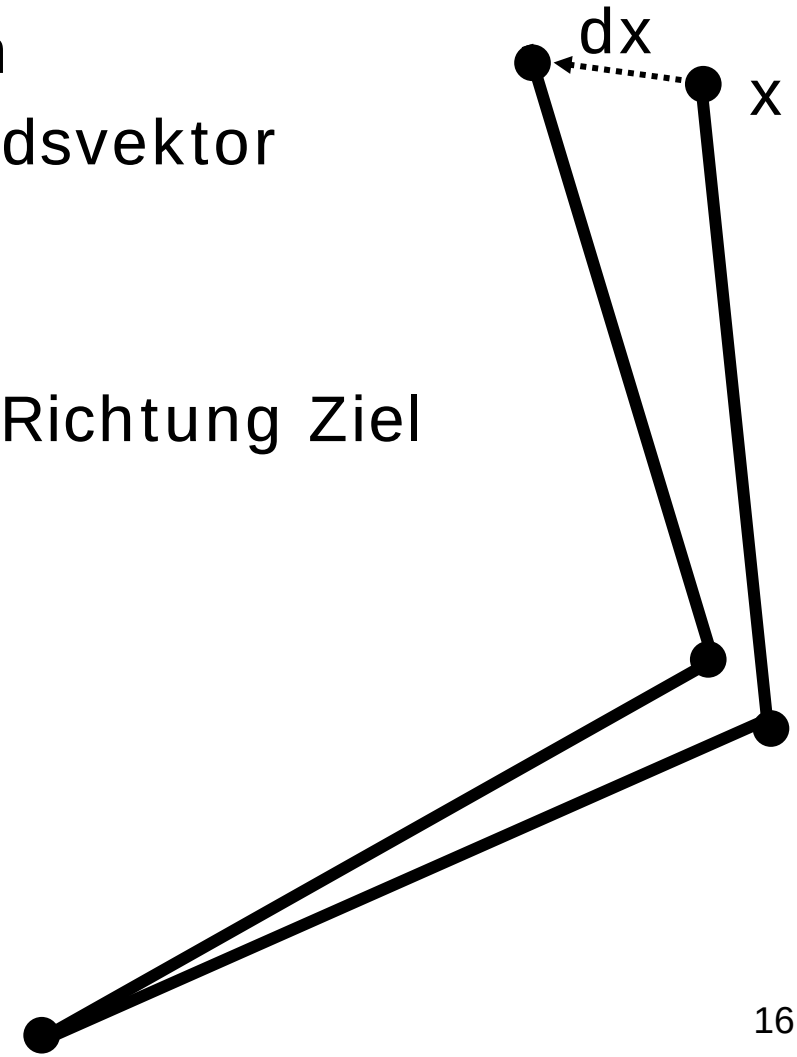
$$\partial\Theta = J(\Theta)^{-1}(\partial\vec{x})$$

Iterationsverfahren

Sei x die aktuelle Position

Sei Θ der aktuelle Zustandsvektor

```
while (!fertig) {
  dx := kleine Bewegung Richtung Ziel
  J(Θ) = dx/dΘ
  berechne Inverse von J
  dΘ := J^-1(Θ)(dx)
  x := f(Θ+dΘ)
}
```



Particle Systems

Geeignet für

- Sand
- Funken
- Wasser
- Schnee
- Feuer
- ...

Simulation physikalischer Gesetze
keine Interaktion untereinander

Pioniere

- William Reeves [1983]:
  "Particle Systems - A Technique for Modeling a Class of Fuzzy Objects"
  ACM Transaction on Graphics
  LucasFilm, Pixar (Luxor Jr.)

- Karl Sims [1990]:
  "Particle Animation and Rendering using Data Parallel Computation"
  ACM Computer Graphics
  Connection Machine CM-2, 65.536 Prozessoren

Partikeleigenschaften

- Position
- Geschwindigkeit
- Bewegungsrichtung
- Lebenszeit
- Größe
- Farbe
- Transparenz
- Gestalt

Phasen

- Generierung neuer Partikel
- Zuordnung von Attributen
- Entfernen von Partikeln
- Transformation von Partikeln
- Rendern des neuen Frames

Physik

Position *P*, Geschwindigkeit *V*, Beschleunigung *A*
Masse m_0 im Zentrum *O*, Flächennormale *N*
Dämpfungsparameter *d*, Grenzgeschwindigkeit v_0

$$A = g \cdot m_0 \cdot \frac{O-P}{|O-P|^3} \qquad F = \frac{g \cdot m_0 \cdot m_1}{r^2}$$

$$V\prime := V + A \cdot \Delta t \qquad A = \frac{F}{m}$$

$$P\prime := P + \frac{V+V\prime}{2} \cdot \Delta t$$

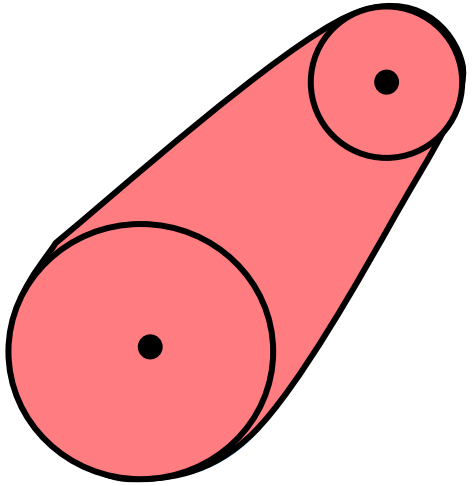
$$V\prime := V - \quad 2 \cdot (V \cdot N) \cdot N$$

$$V\prime = V \cdot \max(1 - d\Delta t, \min(1.0, \frac{v_0}{|V|}))$$

Particle Rendering

Für Head und Tail:

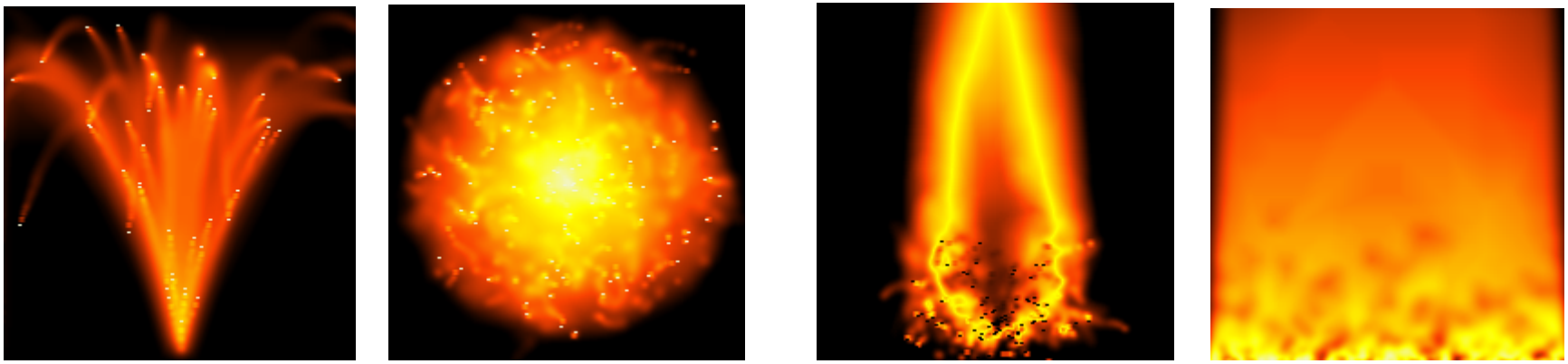
- Position
- Radius
- Farbverlauf
- Transparenz



Motion Blur berücksichtigen !

Particle Systems Demos

~cg/2008/skript/Applets/Particle/sims.html



http://www.jhlabs.com/java/particles2.html

~cg/2008/skript/Applets/Particle/jhlabs.html

~cg/2008/skript/Applets/Particle/kung.html

Pflanzen

white.sand © Alvy Ray Smith, Lucasfilm

Verhaltensanimation

Simple Vehicle Model:

- Masse
- Position
- Fahrtrichtung
- Geschwindigkeit
- Beschleunigung

Vehikel interagiert

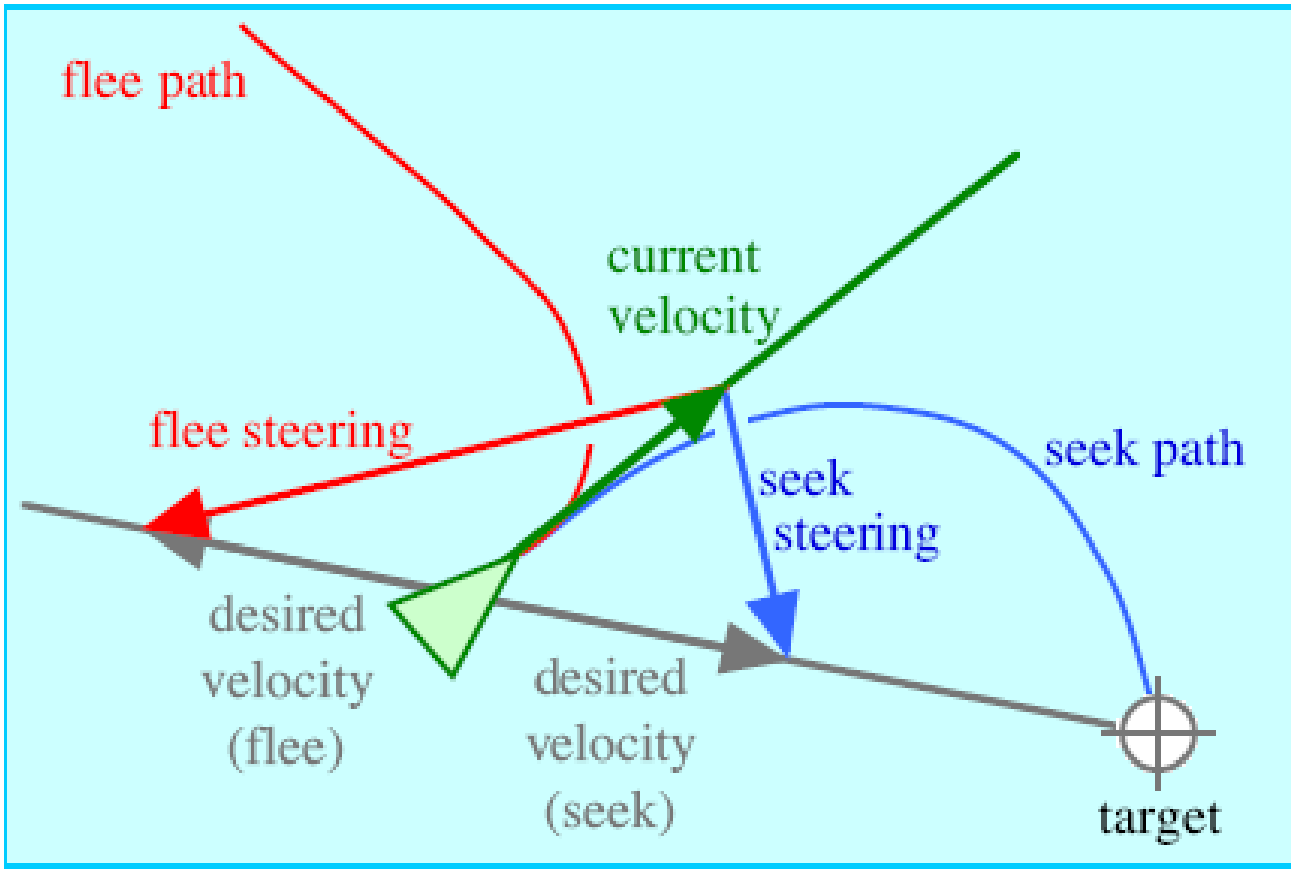
- mit Umweld
- mit anderen Vehikeln

Pionier

- Craig W. Reynolds [1999]:
  Steering Behaviors for autonomous Characters
  [Sony Computer Entertainment]

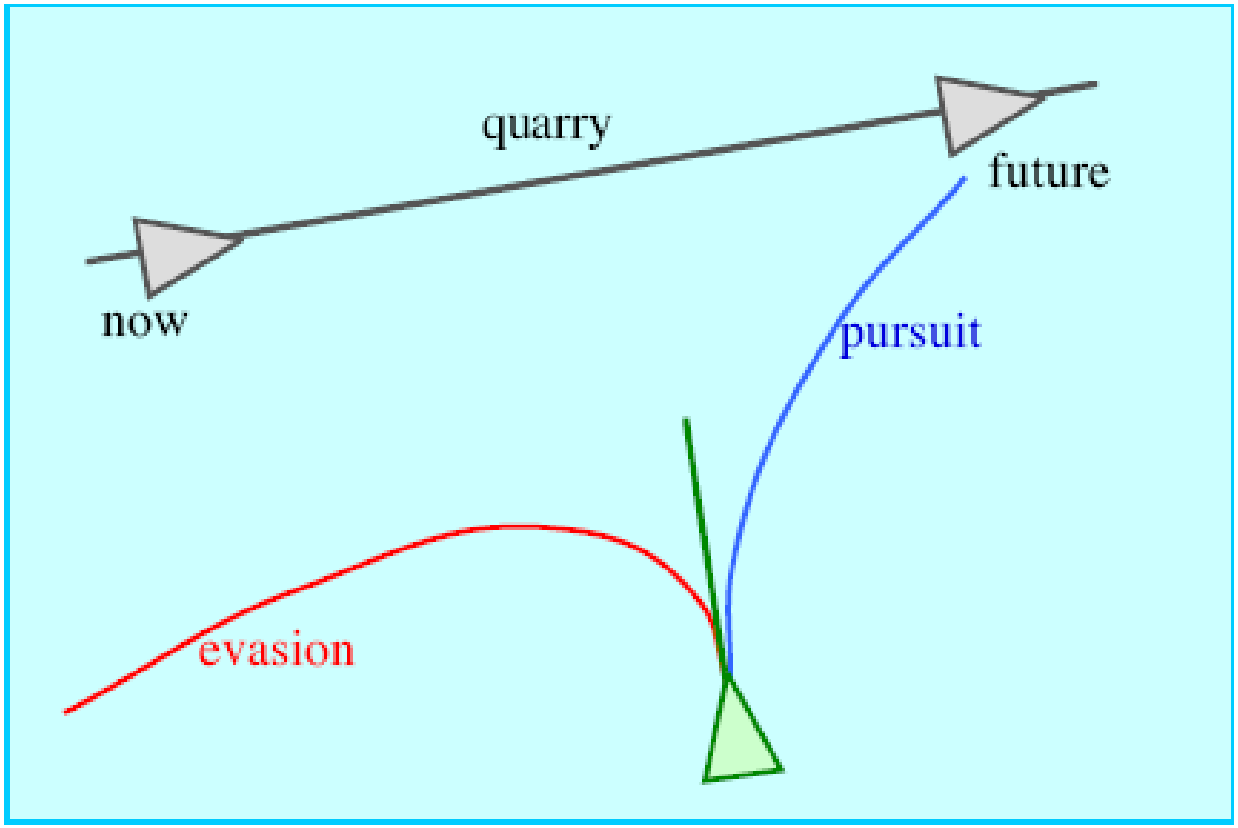
http://www.red3d.com/cwr/steer

Seek & Flee



http://www.red3d.com/cwr/steer/SeekFlee.html

Pursuit & Evasion



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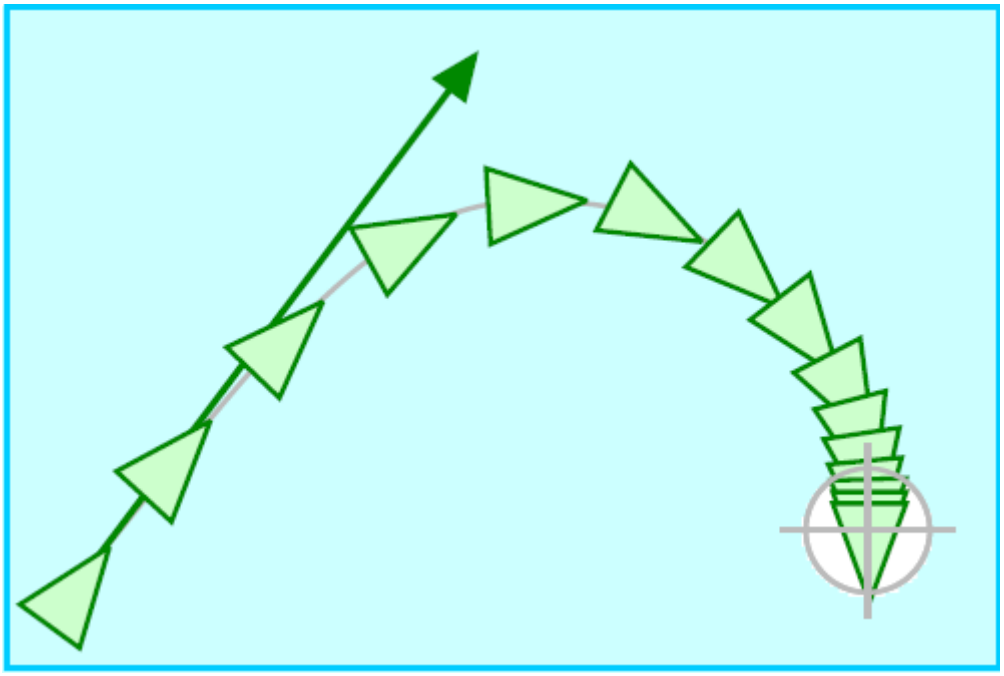
Arrival



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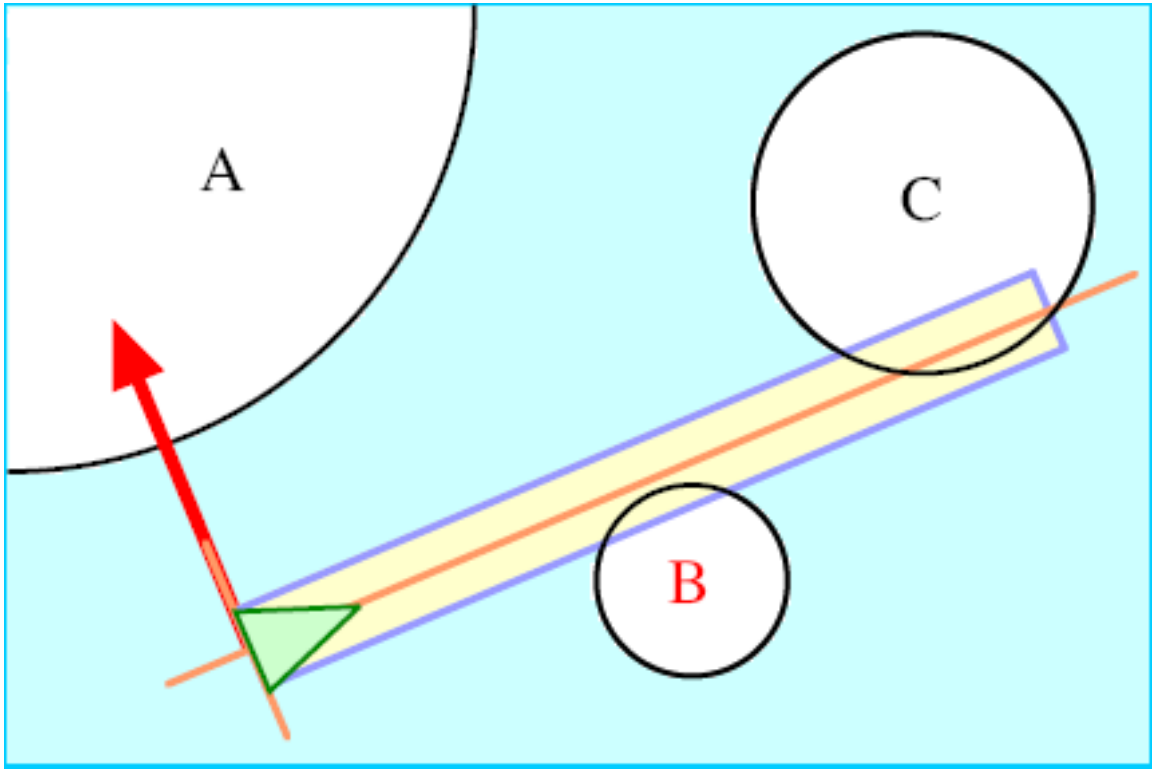
Obstacle Avoidance



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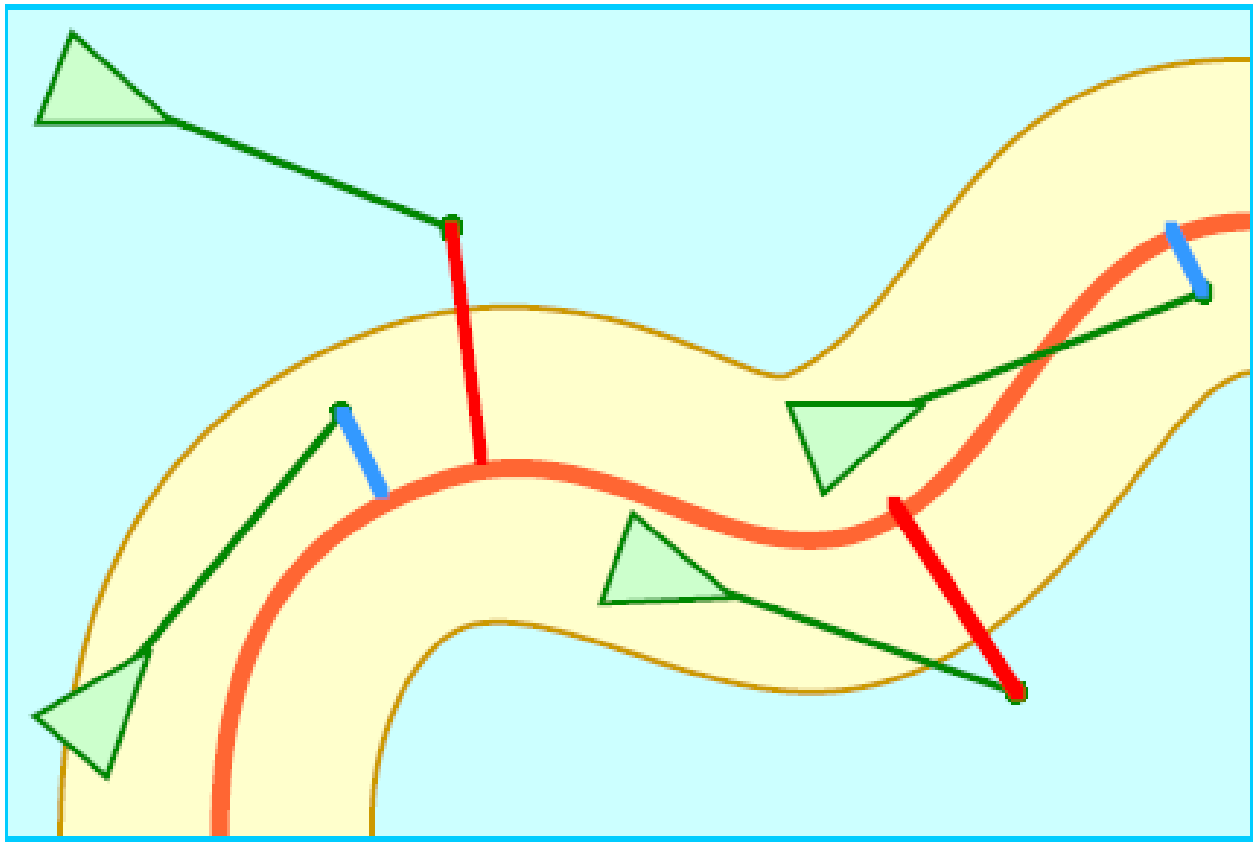
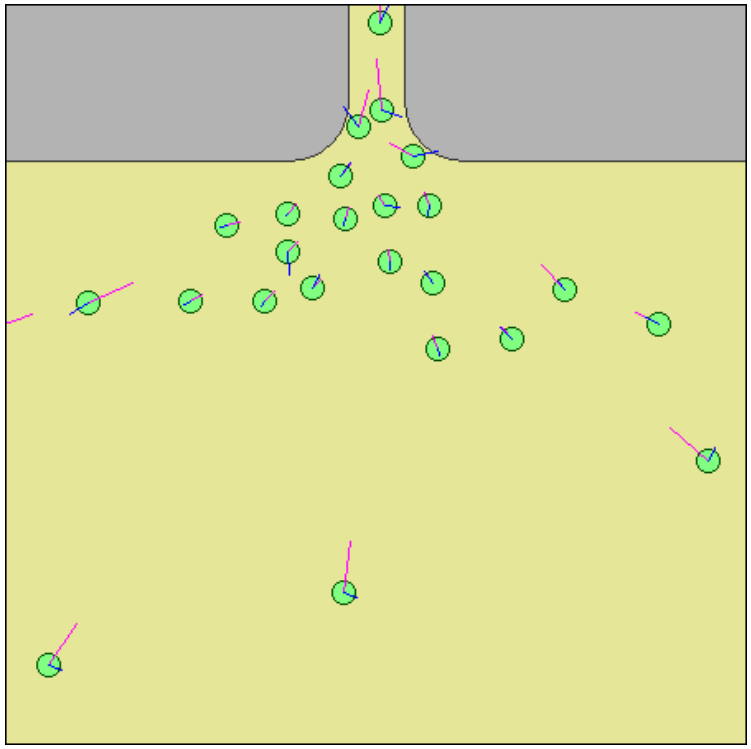
Path Following



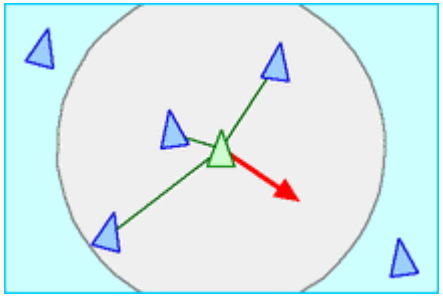
http://www.red3d.com/cwr/steer/PathFollow.html

Queuing Behaviour at door

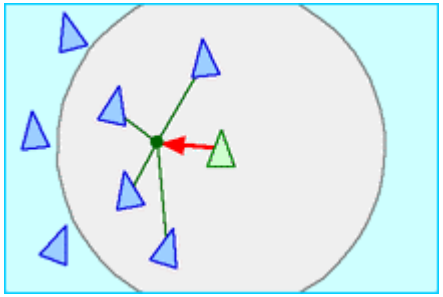


http://www.red3d.com/cwr/steer/Doorway.html

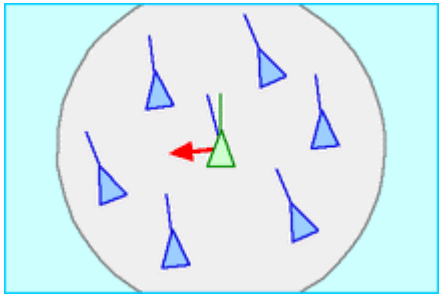
Schwarmverhalten



Separation

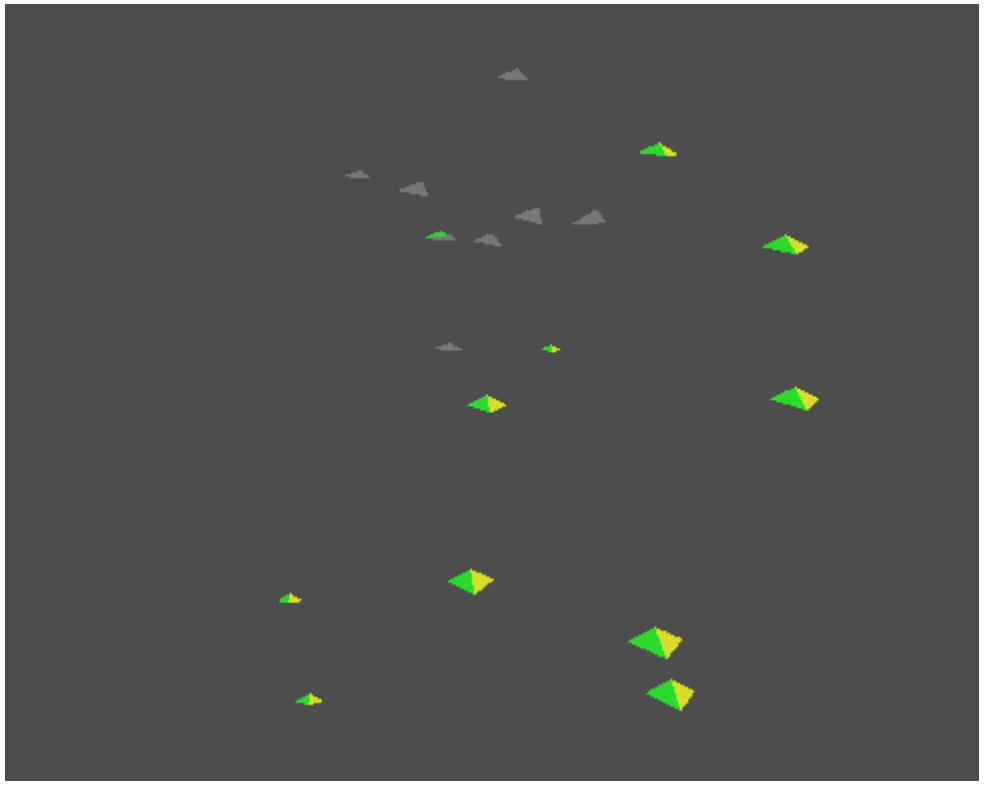


Kohäsion



Ausrichtung

Java Boids



http://www.red3d.com/cwr/boids/applet/

Scanline Production GmbH, München

~cg/2008/skript/Applets/Particle/scanline.htm