



# Physics based piano simulation

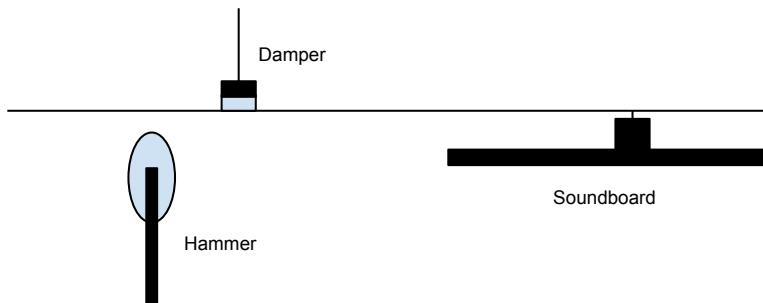
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Delft University of Technology

Selwyn, Kenneth, Daniël

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# Simplified piano string interaction



# The wave equation

$$\frac{\partial^2 y}{\partial t^2} = c^2 \frac{\partial^2 y}{\partial x^2} - \kappa^2 \frac{\partial^4 y}{\partial x^4} - 2b_1 \frac{\partial y}{\partial t} + 2b_2 \frac{\partial^3 y}{\partial x^2 \partial t}$$

# Finite difference wave equation

$$\frac{\partial^2 y}{\partial t^2} = c^2 \frac{\partial^2 y}{\partial x^2} - \kappa^2 \frac{\partial^4 y}{\partial x^4} - 2b_1 \frac{\partial y}{\partial t} + 2b_2 \frac{\partial^3 y}{\partial x^2 \partial t}$$
$$y_n^{t+1} = a_1 (y_{n+2}^t + y_{n-2}^t) + a_2 (y_{n+1}^t + y_{n-1}^t) + a_3 y_n^t$$
$$+ a_4 y_n^{t-1} + a_5 (y_{n+1}^{t-1} + y_{n-1}^{t-1})$$

# Hammer strike

Hammer-string interaction:

# Hammer strike

Hammer release from the string, important for 'plucking' or 'striking' the string.

# Damper simulation

Cutoff sounds unnatural

# Damper simulation

Cutoff sounds unnatural → add damper suppression



# Damper simulation

Cutoff sounds unnatural → add damper suppression  
Increase stiffness

# Damper simulation

VERGELIJKINGSPLAATJES

# Examples

Time for some 'music' !

# Considerations

- Add more notes

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- Real-time playback

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- Add more notes
- Real-time playback
- Simulate three strings of same pitch with slightly different parameters

Thank you!