15-464/15-664 Reference List for April 15th 2020

We began by talking about state machine based control, beginning with papers from the 90's:

Raibert, Marc H., and Jessica K. Hodgins. "Animation of dynamic legged locomotion." In *ACM SIGGRAPH Computer Graphics*, vol. 25, no. 4, pp. 349-358. ACM, 1991.
http://dl.acm.org/citation.cfm?id=122755&dl=ACM&coll=DL&CFID=657285216&CFTOKEN=27654732

The video I showed can be found here: http://www.ai.mit.edu/projects/leglab/simulations/otr/otr.html

Jessica K. Hodgins, Wayne L. Wooten, David C. Brogan, and James F. O'Brien. 1995. Animating human athletics. In *Proceedings of the 22nd annual conference on Computer graphics and interactive techniques* (SIGGRAPH '95), Susan G. Mair and Robert Cook (Eds.). ACM, New York, NY, USA, 71-78. DOI=10.1145/218380.218414 http://doi.acm.org/10.1145/218380.218414

The video can be found here: http://graphics.cs.cmu.edu/?p=689

Yin, KangKang, Kevin Loken, and Michiel van de Panne. "Simbicon: Simple biped locomotion control." In *ACM Transactions on Graphics (TOG)*, vol. 26, no. 3, p. 105. ACM, 2007.
http://www.cs.ubc.ca/~van/papers/Simbicon.htm

Coros, Stelian, Philippe Beaudoin, and Michiel van de Panne. "Generalized biped walking control." *ACM Transactions on Graphics (TOG)*. Vol. 29. No. 4. ACM, 2010.
http://www.cs.ubc.ca/~van/papers/2010-TOG-gbwc/

https://www.cs.ubc.ca/~van/papers/2010-TOG-gbwc/
https://www.youtube.com/watch?v=lOxeyyooDmw
https://www.youtube.com/watch?v=MHj8RDfyqP0

Coros, Stelian, et al. "Locomotion skills for simulated quadrupeds." *ACM Transactions on Graphics (TOG)*. Vol. 30. No. 4. ACM, 2011. http://www.cs.ubc.ca/~van/papers/2011-TOG-quadruped/index.html

For follow-up reading, this reference is very thorough, and contains a great deal of background material up to 2011:

Geijtenbeek, Thomas, Nicolas Pronost, Arjan Egges, and Mark H. Overmars. "Interactive character animation using simulated physics." *Eurographics-state of the art reports* 2 (2011).
http://www.cs.uu.nl/docs/vakken/mgp/literature/Interactive%20Character%20Animation%20Using%20Simulated%20Physics%20-%20A%20State-of-the-Art%20Review.pdf

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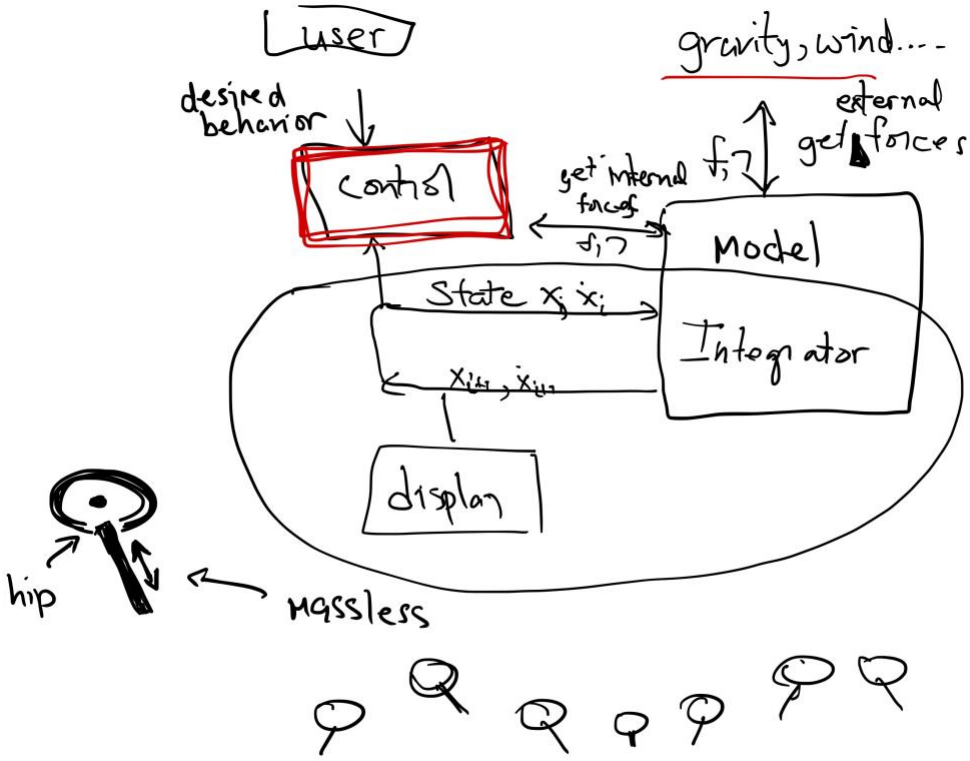
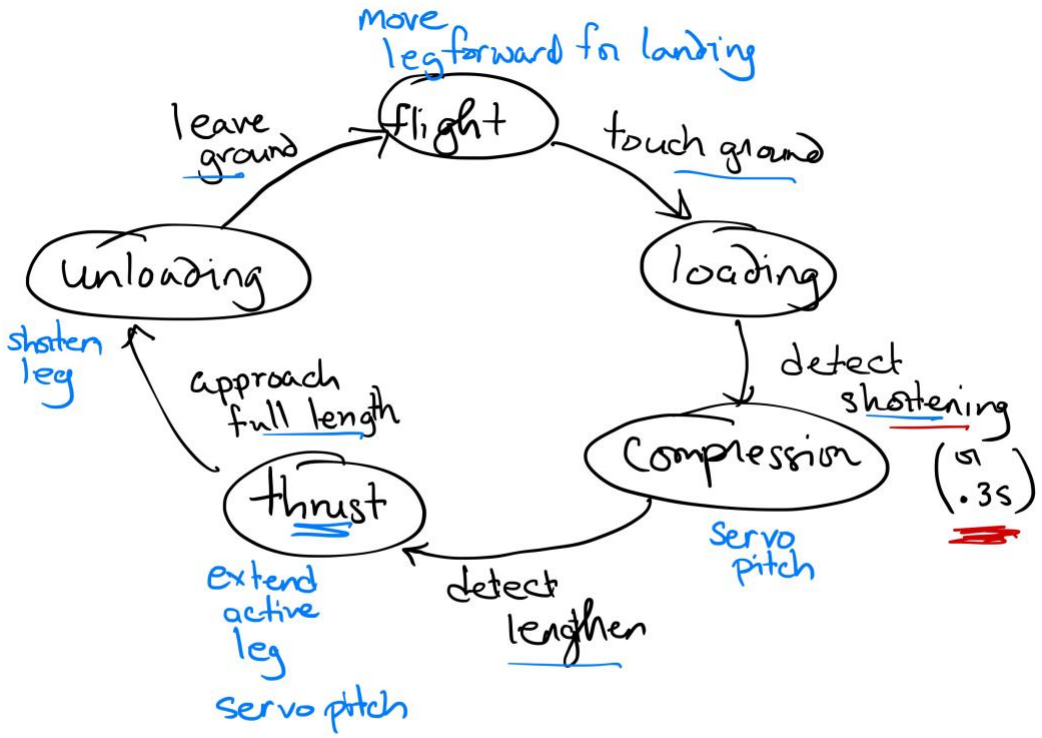
Whiteboard notes follow.


User
desired behavior
control
gravity, wind....
external forces
get internal forces
f_i
Model
State x_i ẋ_i
Integrator
x_i+1, ẋ_i+1
display
hip
massless


move leg forward for landing
flight
leave ground
touch ground
unloading
loading
shorten leg
approach full length
detect shortening
(≈ .3s)
Compression
thrust
Servo pitch
extend active leg
detect lengthen
servo pitch

Hopping Control

$$Mgh = PE_{Strain} + PE_{Elevation} + KE$$

h: hop height

$PE_{Strain} + PE_{Elevation}$: leg spring

$$h = (PE_{Strain} + PE_{Elevation} + KE) / Mg$$

Hop height
Speed
Posture

leg spring

$$f = k(x - x_r) + b\dot{x}$$

k: stiffness
x_r: rest length
b: damping

x_r: free variable

Solve for x_r to control hopping height

Speed Control

accelerate forward

continue at calculated / desired velocity

slow down

Posture Control

$$\tau = -K_p(\phi - \phi_d) - K_v(\dot{\phi})$$

Δ

spring

damper

PD controller