Legged Locomotion in Robots and Animals

Special Subject 6.894

Fall, 1999

Class meetings: 2:00pm-5:00pm, Tuesdays, Rm NE43-941.
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Intensive Introduction to the principles of legged locomotion, as they apply to walking robots and animals. Topics: selection and coordination of gait, energetics and speed, mechanical design, evolution of legged creatures, control of balance, algorithms for rough terrain, and gymnastics. Students required to complete a project on a related topic.

Handout No. 01 September 14, 1999

Date	Topic	Readings
Sept 14	Introduction	Lecture and videotapes
Sept 21	Biomechanics, Energetics, and Control	
	Spinal patterns	Pearson (1976)
	Mechanics of walking	McMahon (1984)
	Human walking	Margaria (1976)
Sept 28	Passive Dynamics	
	Passive Layout Somersaults	Playter (1995)
	Ballistic walking	Mochon & McMahon (1980)
	Passive dynamic walking	McGeer (1990)
Oct 5	Bipedal Walking Robots I	
	WL-12RV	Waseda (1993)
	P2 & P3	Honda (1998)
	Biper	Miura & Shimoyama (1984)
Oct 12	Bipedal Walking Robots II	
	Meltran	Kajita et al. (1992)
	Timmy	Dunn & Howe (1996)
	Spring Flamingo	Pratt & Pratt (1998)

Oct 19	Running: Role of compliance	
	Three uses of springs	Alexander (1990)
	Compliance and gait	McMahon (1985)
	Robot running	Raibert et al. (1986)
Oct 26	Is gait a coupled oscillation?	
	Central pattern generators	Grillner
	Neural Oscillator Control of Walking	Taga
	Mechanical coupling	TBD
Nov 2	Scaling	
	Elastic similarity	McMahon (1975)
	Dynamic similarity	Alexander (1977)
	Dinosaurs	Alexander (1990)
	Dinosaur Gaits	Thulborn (1989)
Nov 9	Energetics	
	Vehicle speed/cost	Gabrielli & von Karmen (1950)
	Metabolic efficiency	Taylor(1980), Taylor et al.(1980)
	Load carrying	Maloiy et al. (1986)
Nov 16	Design, Actuation	
	power/weight	TBD
	force control/position control	
	materials	
	"bandwidth"	
	transmission	
	design optimization	
Nov 23	Design, Evolution, and Learning	
	Learning to Walk	Miller (1994)
	Genetic Algorithms	Sims (1995)
	Animal Evolution	TBD
Nov 30	Rough Terrain and Maneuvers	
	Robot foot placement	Hodgins & Raibert (1991)
	Diving	Frohlich (1979)
	Twisting somersaults	Yeadon (1986)
	Robot Gymnastics	Hodgins & Raibert
Dec 7	Project Presentations	

Readings

Alexander, R. McN. 1977. Mechanics and scaling of terrestrial locomotion. In *Scale Effects in Animal Locomotion*, T. J. Pedley (ed.). London: Academic Press, 93–110.

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Alexander, R. McN., Langman, V. A., and Jayes, A. S. 1977. Fast locomotion of some African ungulates. *J. Zoology, (London)* 183:291–300.

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Kajita, S., Yamaura, T., Kobayashi, A. 1992. Dynamic Walking Control of a Biped Robot Along a Potential Energy Conserving Orbit. *IEEE Transactions on Robotics and Automation*, Vol. 8, No. 4: 431–438.

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7. Dawson, Kangaroos, 1977

8. Sonstegard, Matthews, and Kaufer, The surgical replacement of the human knee joint, 1978

9. McMahon and Greene, Fast running tracks, 1978

10. Frohlich, The Physics of somersaulting and twisting, 1980

11. Raibert and Sutherland, Machines that walk, 1983

12. Alexander, How Dinosaurs Ran, 1991