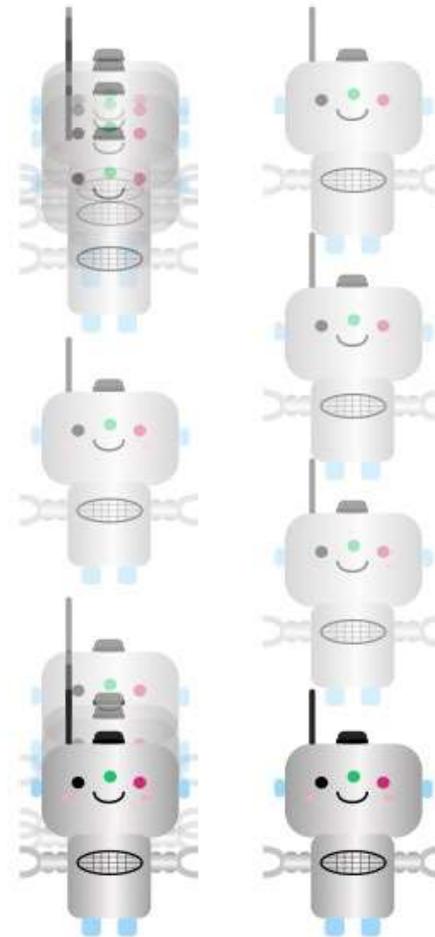


Making Robots Move Using Animation Techniques

Trenton Schulz
PhD Candidate
Research Group for Design of
Information Systems
University of Oslo

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Slow in/Slow out

Constant Speed



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The Research
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MECS
Multimodal Elderly Care Systems



I will present an argument for designing robots with motion, some principles of animation, and then show an implementation



Designing Robots with Motion in Mind

Principles of animation

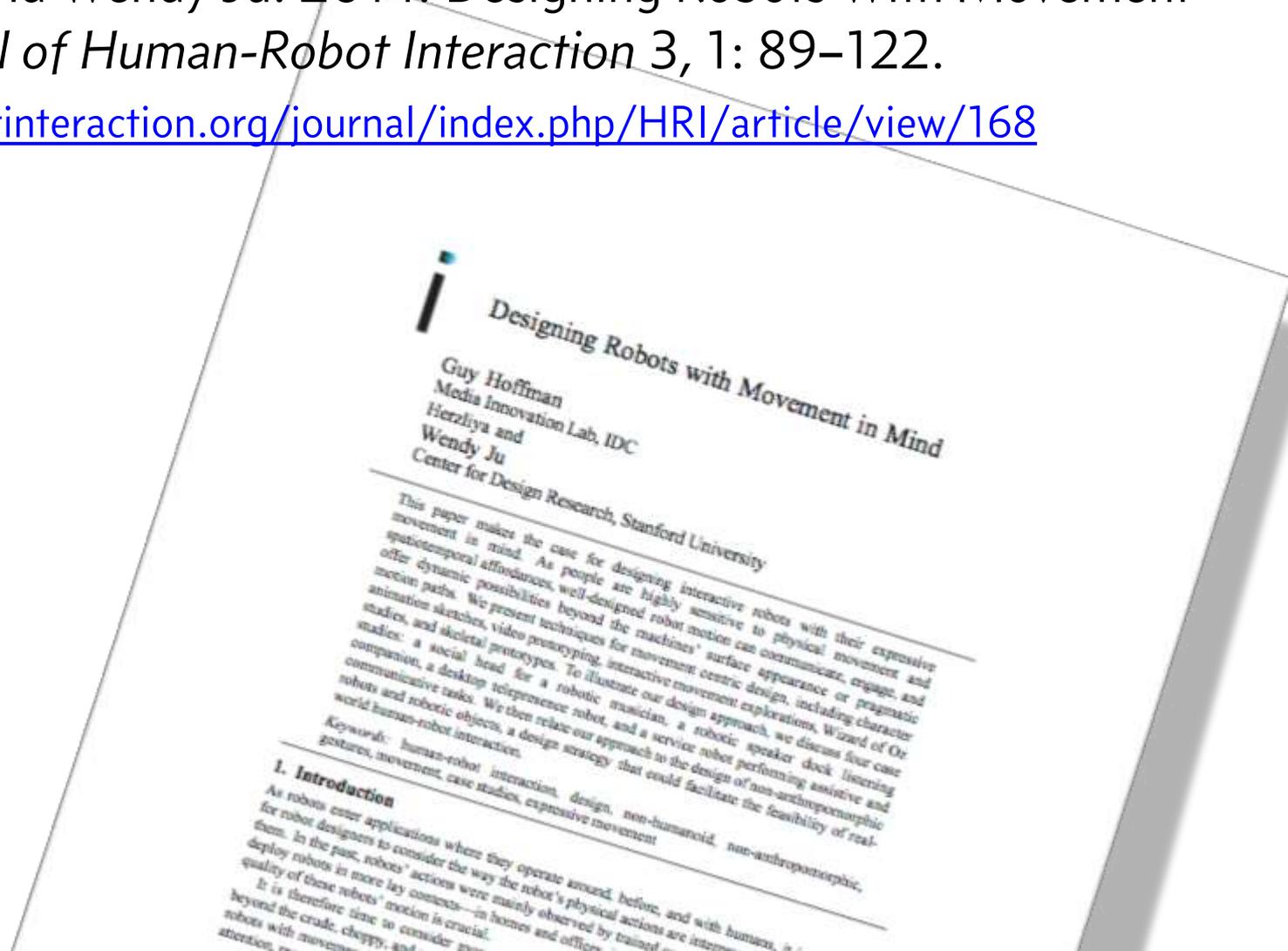


An implementation of Slow in & Slow out

Let's start with looking at *Designing Robots with Movement in Mind* by Hoffman and Ju

Guy Hoffman and Wendy Ju. 2014. Designing Robots With Movement in Mind. *Journal of Human-Robot Interaction* 3, 1: 89–122.

<http://humanrobotinteraction.org/journal/index.php/HRI/article/view/168>



Hoffman and Ju start by contrasting different approaches for designing robots

Pragmatic Approach—Design a robot based on engineering requirements



Visual Approach—Design a robot based on its appearance

Hoffman and Ju argue that designing for motion is important for human-robot interaction

People notice motion...

Motion communicates...

Motion provides dynamic affordances...



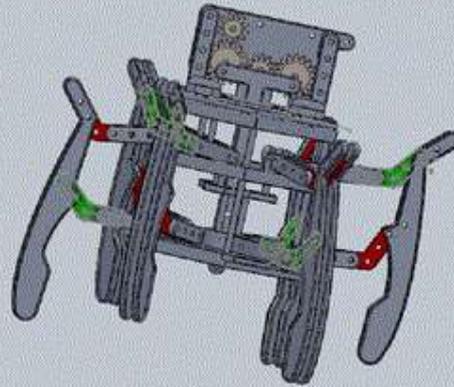
There are several ways to design with motion in mind:

3D Animation Gesture Studios

Skeleton Prototype

Wizard of Oz

Video Prototyping



One case study is using Shimon, a marimba-playing robot that improvises with other human players

<https://youtu.be/qy02lwvGv3U>

Shimon grew a head for making it easier to collaborate with multiple musicians

https://youtu.be/jtC_CNPiGe8

Travis is an example of using many techniques to create a final moving robot

<https://youtu.be/EhEPWnRxxqM>

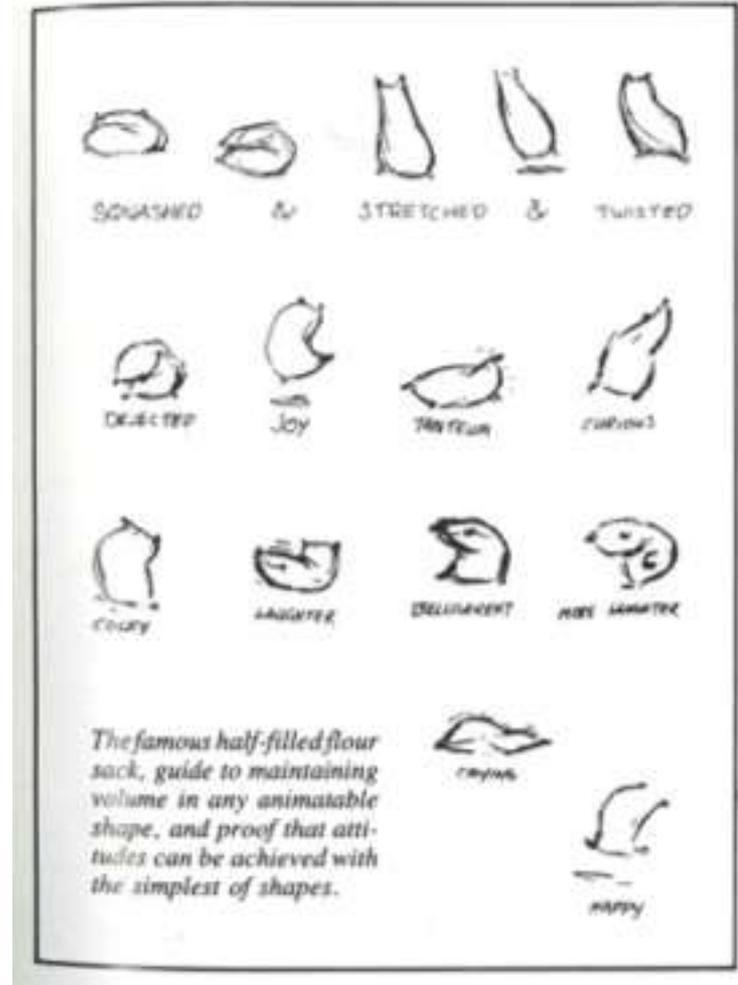
In summary, building robots with motion in mind can be a good way of approaching a design issue with robots

Thomas and Johnston documented the Twelve Principles of Animation

1. Squash and Stretch
2. Anticipation
3. Staging
4. Straight Ahead Action and Pose to Pose
5. Follow Through and Overlapping Action
6. Slow In and Slow Out
7. Arcs
8. Secondary Action
9. Timing
10. Exaggeration
11. Solid Drawing
12. Appeal

Source: Frank Thomas and Ollie Johnston. 1995. *The Illusion of Life: Disney Animation*. Hyperion, New York.

Squash and stretch—objects should squash and stretch, but they should not lose their shape



Source: Thomas & Johnston p. 49

Squash and stretch—objects should squash and stretch, but they should not lose their shape

<https://youtu.be/JxmZyEH4IVI>

Anticipation—Major action should be telegraphed

Source: Thomas & Johnston, p. 52

Donald draws back with raised leg in anticipation of the dash he will make out of the scene.



Straight Ahead Action and Pose to Pose—Just have action happen or set up certain poses and interpolate between.



Follow Through and Overlapping Action—Actions are not performed in isolation; they lead into each other

Source: Thomas & Johnston, p. 59

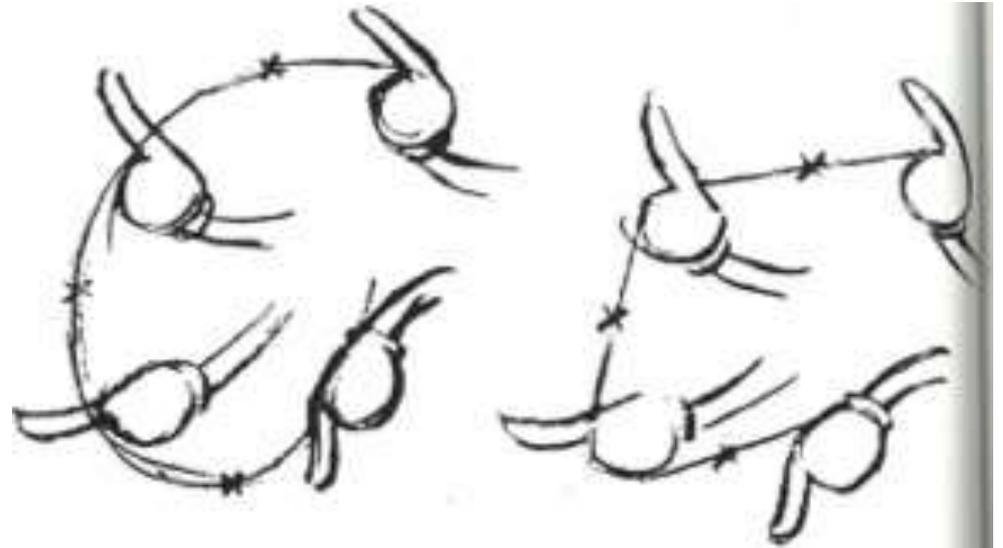


Slow In and Slow Out—Action is slower at the beginning and the end of an action



Arcs—Move limbs in arcs as opposed to of straight up-down and left-right motions

Thomas & Johnston, p. 62



The action of a hand gesture with a pointing finger follows a circular path. The animator charts the position of his drawings along this arc. He makes his key drawings, indicating where inbetweens should be placed to keep the line of action on this arc. Inbetweens done without following this arc change the action radically.

Secondary Action—Complementary actions that emphasize the main action

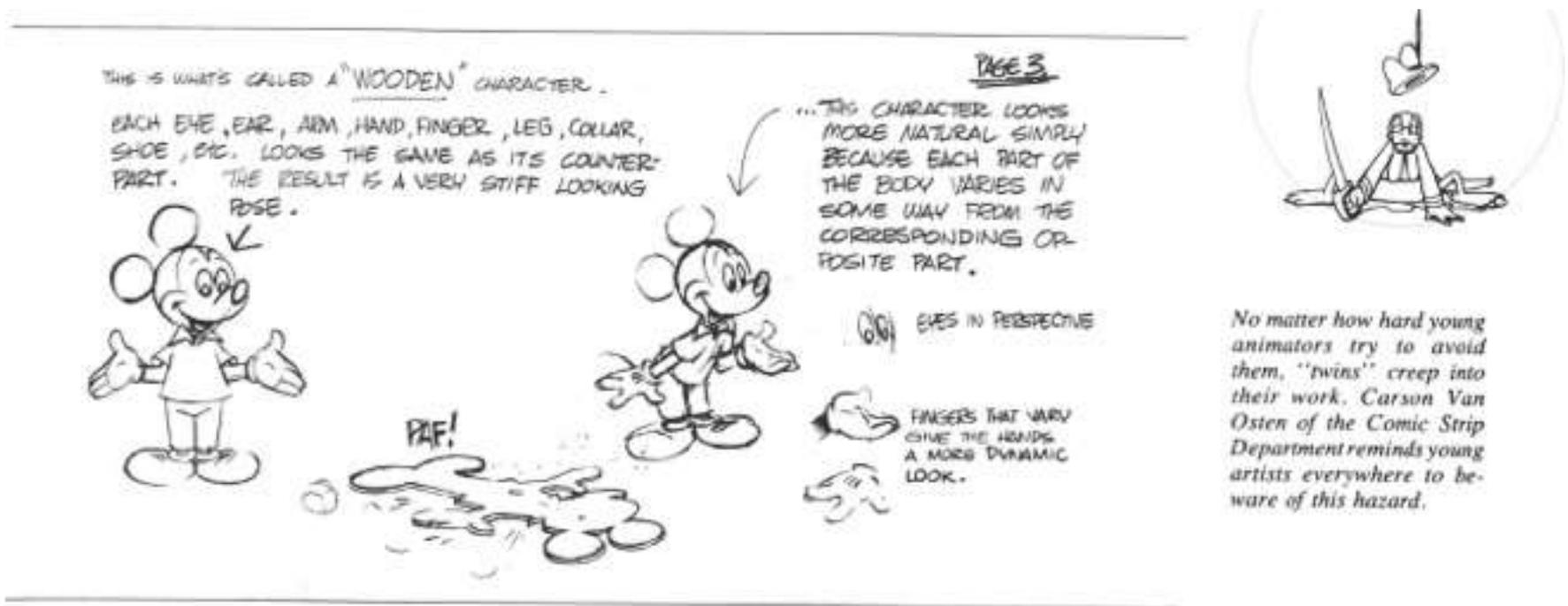
[https://youtu.be/ 2mGWPeJU00](https://youtu.be/2mGWPeJU00)

Exaggeration—Exaggerated motion makes it easier to read a characters emotion

<https://youtu.be/CL0qxUWekMU>

Solid Drawing—Avoid twins: symmetrical limbs on a character

Source: Thomas and Johnston, p. 67



Group activity, try to think about how you could use motion or animation in designing robots for different situations

<https://youtu.be/4RZn15EdMbo>

Slow in and slow out has multiple ways to be implemented

<https://youtu.be/fQBFsTqbKhY>

Slow in and slow out uses easing curves to specify *movement*, but robots control their *speed*, not their movement

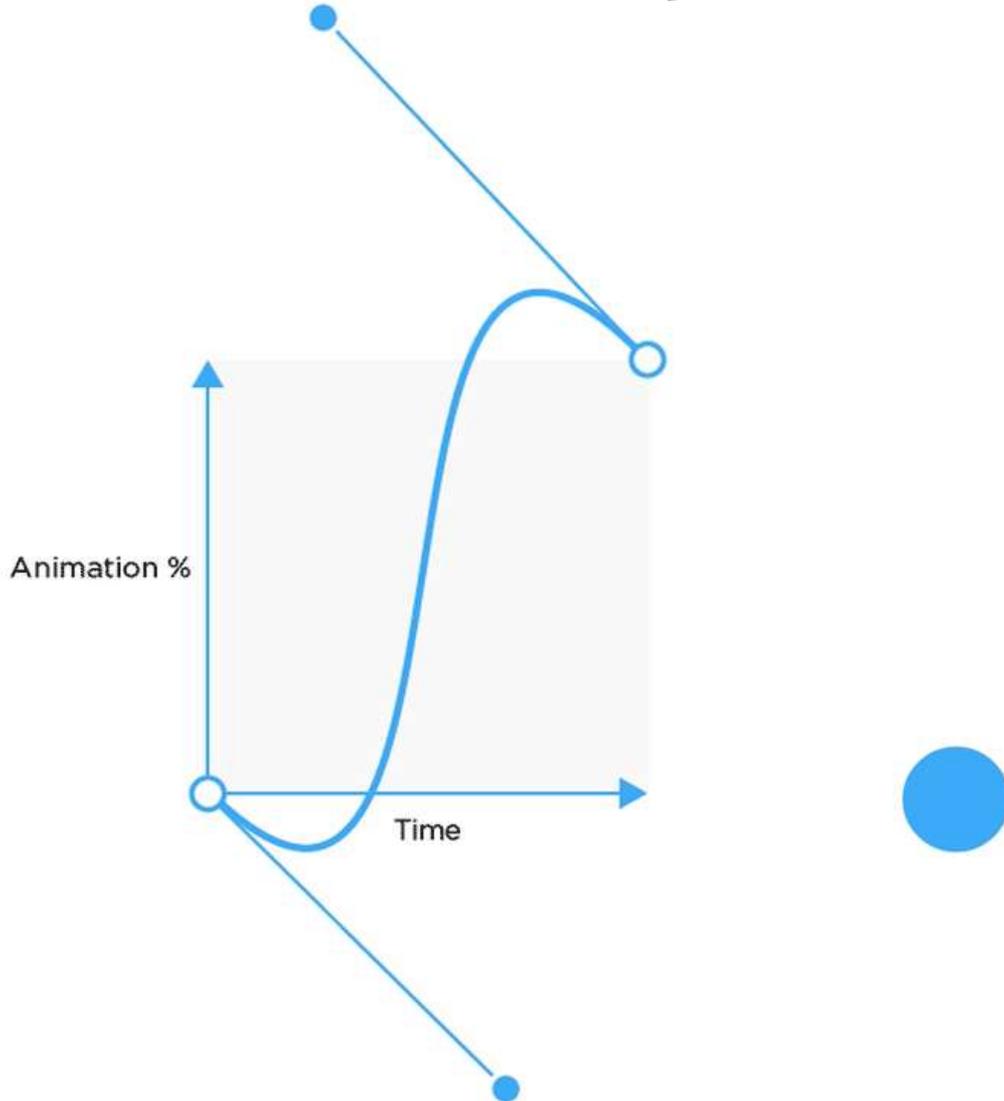
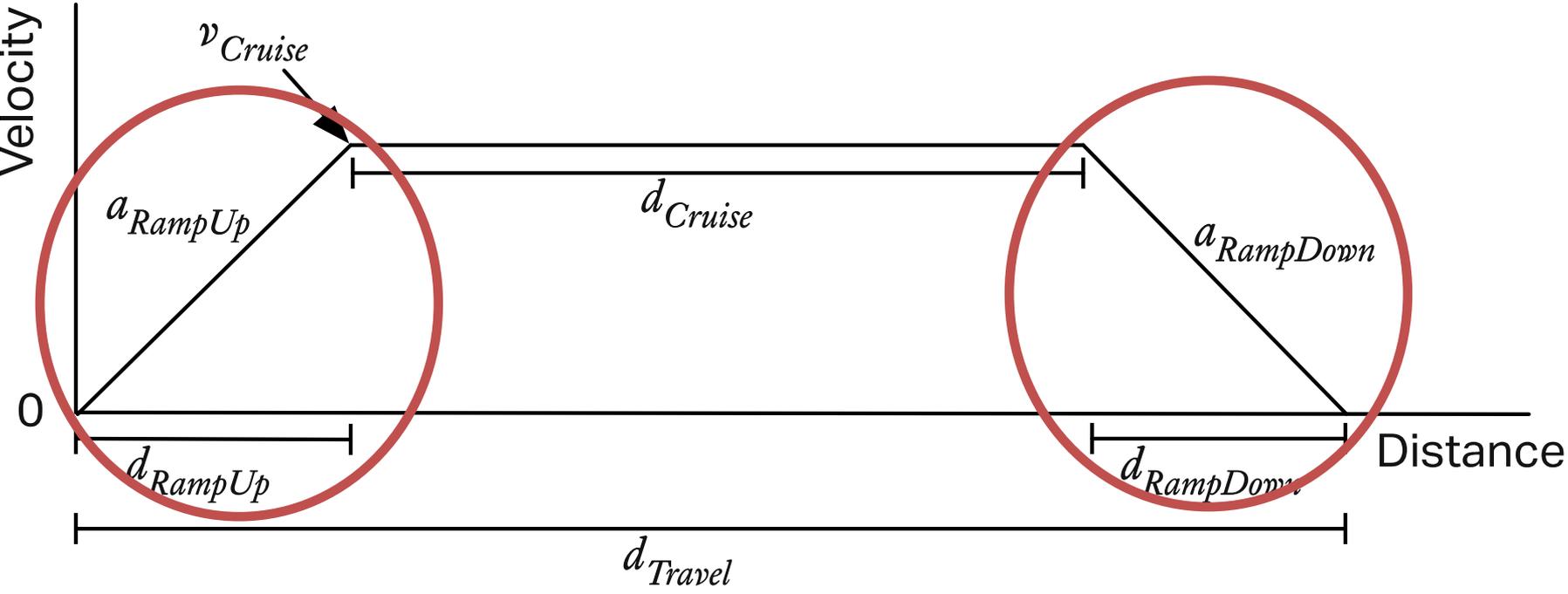
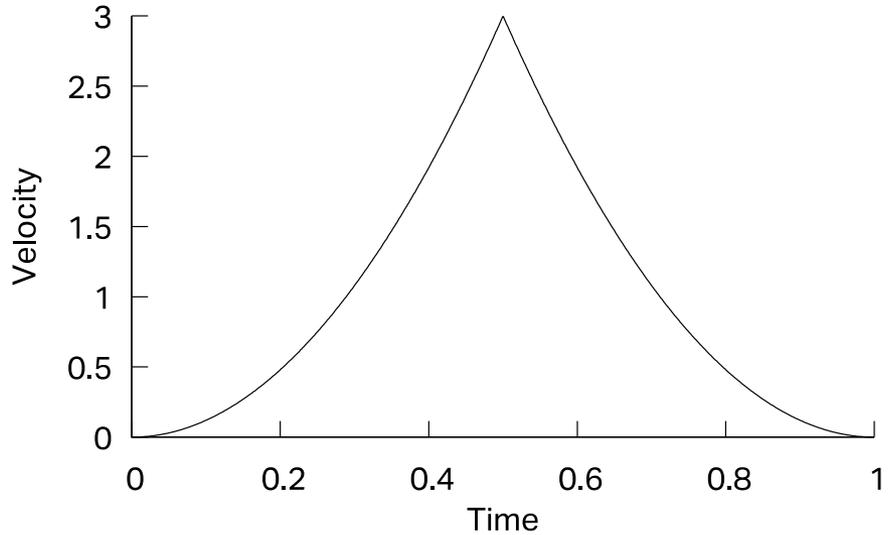
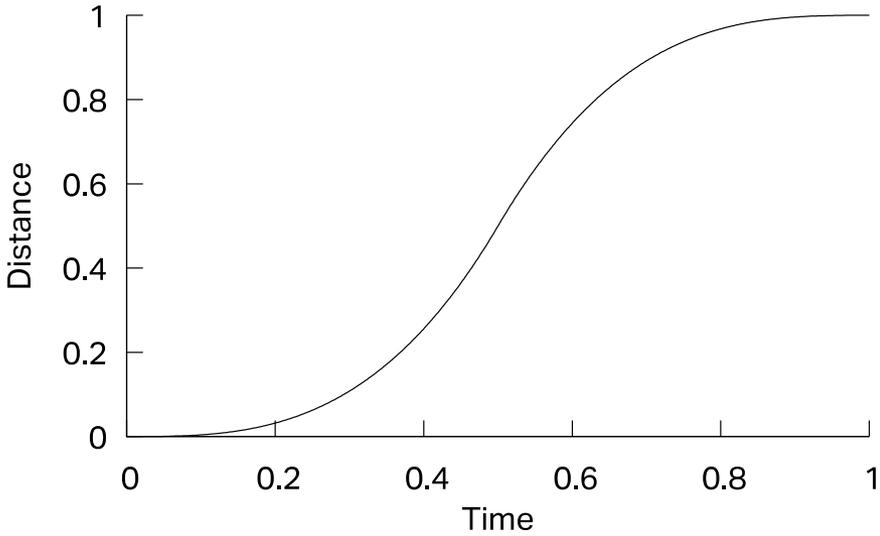


Image source: https://medium.com/@ryan_brownhill/crafting-easing-curves-for-user-interfaces-34f39e1b4a43

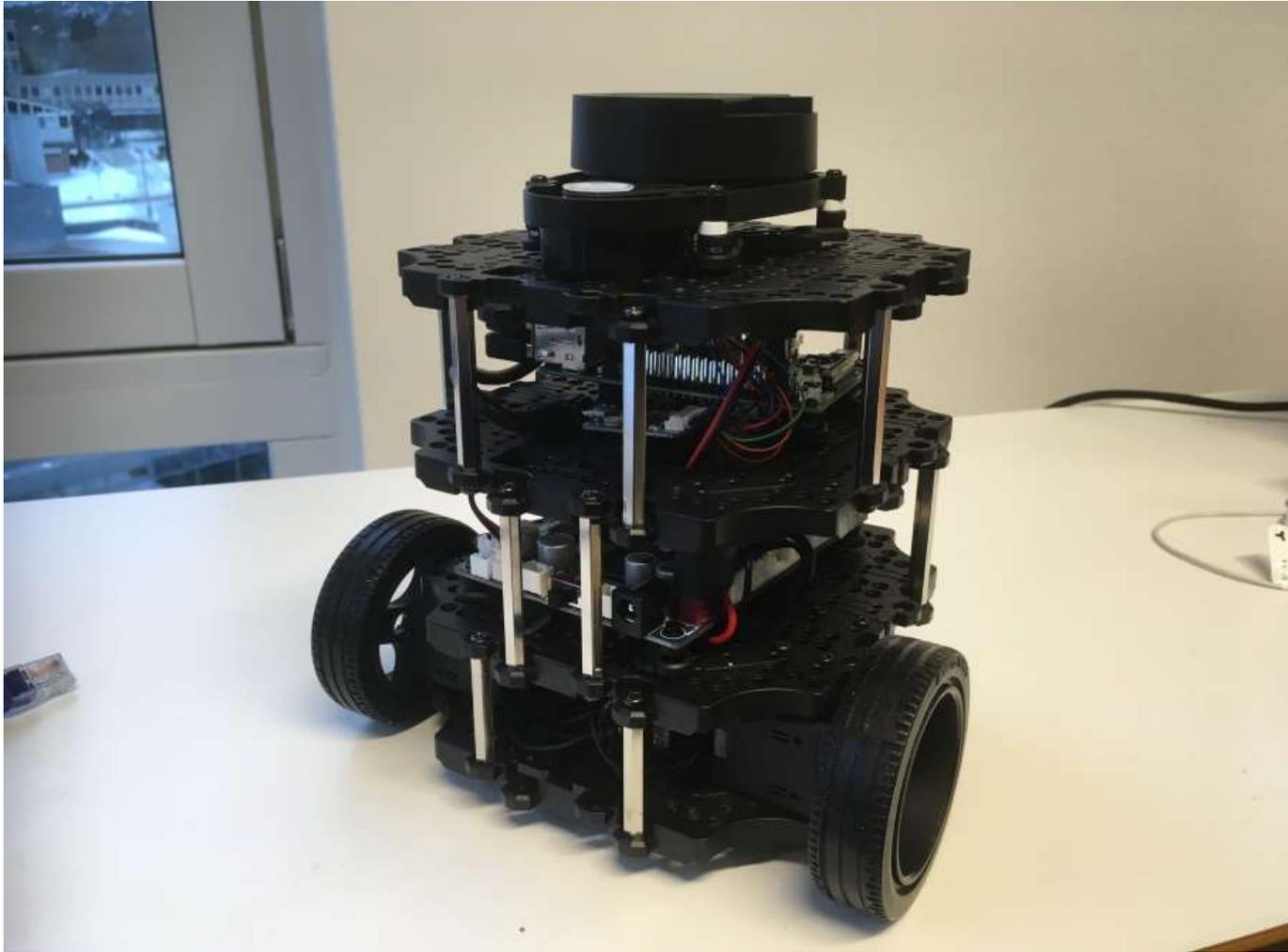
Robots movement can be graphed as a velocity profile of velocity over distance



Using Calculus, we can take the derivative of an easing curve and use it to get the velocity



Demo goes here...



In summary, animation techniques aid in designing robots with motion in mind

<https://youtu.be/jt4CfFIM6II>

I need some volunteers for piloting a study...