

Learning Haptic Representation for Manipulating Deformable Food Objects

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1 Reward Functions

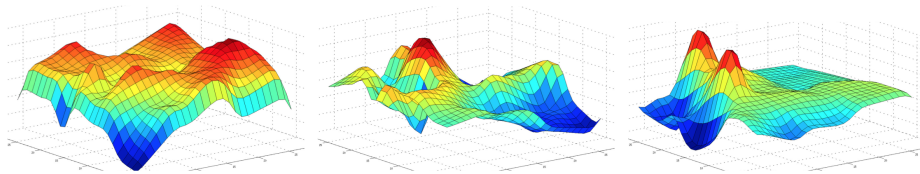


Figure 1: **Reward Functions for some of the actions, from left to right, split with grippers, cut with saw-like motion, move with spatula, in hardness-plasticity subspace.**

The reward functions are manually constructed from distance weighted linear extrapolation of values $\{1, 0 - 1\}$ that are assigned to different categories of food for different actions by human experts based on their knowledge on which actions would be the best to use in general on a given category for a specific subgoal. Since the reward function is defined over the whole property space for each action, it is a surface in $(6 + 1)$ dimensional space. Above we show reward functions for three different actions that would be obtained if there was only 2 physical properties (surface in $(2 + 1)$ dimensional space), *hardness-plasticity*. More explicitly, each graphs is obtained from a weighted interpolation based on these two properties only, in order to visualize the reward functions. The full reward function is hard to visualize since it is a high dimensional surface.

2 Ordering of Property Labels for Object Categories

$O_{\text{Hardness}} = [\text{Cucumber} \sim \text{Apple} \succ \text{Banana} \succ \text{Bagel} \succ \text{Cheddar Cheese} \succ \text{Tomato} \succ \text{Bread} \succ \text{Soft Buns} \sim \text{Peeled Banana} \sim \text{Cream Cheese} \succ \text{Lettuce}]$

$O_{\text{Elasticity}} = [\text{Banana} \succ \text{Tomato} \succ \text{Lettuce} \succ \text{Cucumber} \succ \text{Soft Bun} \succ \text{Bread} \succ \text{Apple} \sim \text{Bagel} \succ \text{Peeled Banana} \sim \text{Cheddar Cheese} \succ \text{Cream Cheese}]$

$O_{\text{Plasticity}} = [\text{Cucumber} \succ \text{Cheddar Cheese} \succ \text{Soft Bun} \succ \text{Peeled Banana} \succ \text{Apple} \succ \text{Cream Cheese} \succ \text{Tomato} \succ \text{Banana} \sim \text{Bagel} \succ \text{Lettuce} \succ \text{Bread}]$

$O_{\text{Tensile Strength}} = [\text{Cucumber} \sim \text{Apple} \succ \text{Banana} \succ \text{Tomato} \succ \text{Cheddar Cheese} \succ \text{Lettuce} \succ \text{Bagel} \succ \text{Peeled Banana} \sim \text{Cream Cheese} \succ \text{Bread} \succ \text{Soft Bun}]$

$O_{\text{Brittleness}} = [\text{Cream Cheese} \sim \text{Peeled Banana} \succ \text{Cheddar Cheese} \succ \text{Bagel} \succ \text{Soft Bun} \succ \text{Lettuce} \succ \text{Tomato} \sim \text{Banana} \sim \text{Bread} \sim \text{Cucumber} \sim \text{Apple}]$

$O_{\text{Adhesiveness}} = [\text{Cream Cheese} \succ \text{Peeled Banana} \succ \text{Cheddar Cheese} \succ \text{Banana} \sim \text{Bagel} \sim \text{Lettuce} \sim \text{Tomato} \sim \text{Bread} \sim \text{Soft Bun} \sim \text{Cucumber} \sim \text{Apple}]$