ECT* Workshop

Machine Learning and the Renormalization Group
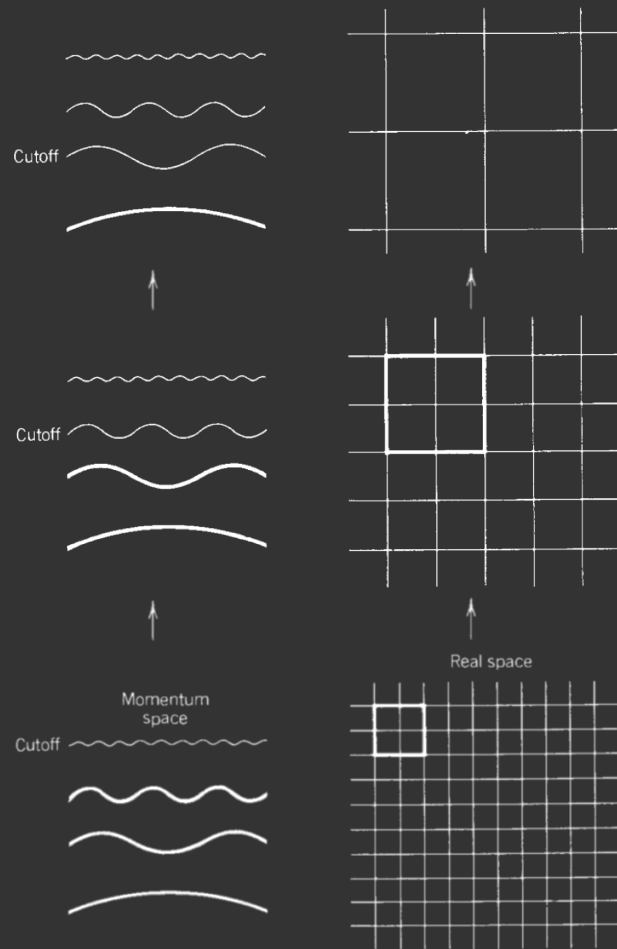
Huang, Statistical Mechanics
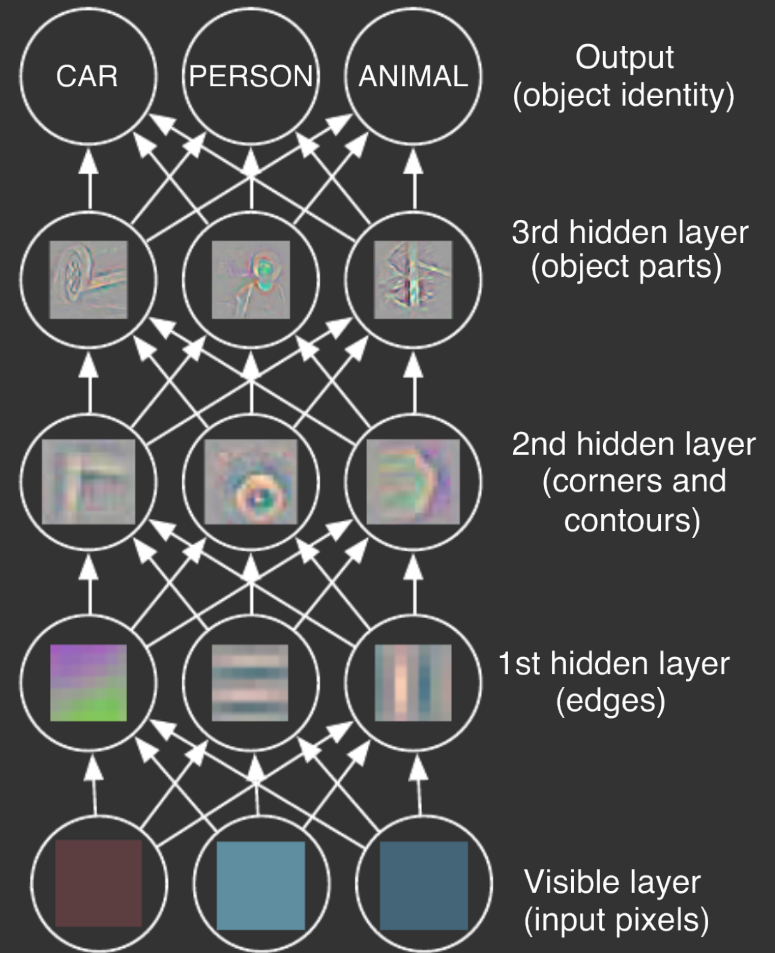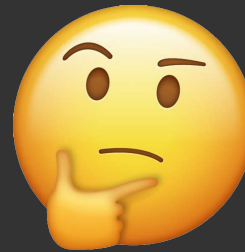
Goodfellow, Deep Learning

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A Brief Early History of Renormalization

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- Stueckelberg: (lost) manuscript on renormalization for QED (~1942)

- Tomonaga, Schwinger, Feynman: radiative corrections in QED (1946-48)

- Stueckelberg & Petermann: *La renormalisation des constants dans la théorie de quanta* (1953)

- Gell-Mann & Low: *Quantum Electrodynamics at Small Distances* (1954)

- Kadanoff: *Scaling laws for Ising models near T_c* (1966)

- Callan: *Broken Scale Invariance in Scalar Field Theory* (1970)

- Symanzik: *Small distance behaviour in field theory and power counting* (1970)

- Wilson: *Renormalization group and critical phenomena* (1971)

Inspiration

An exact mapping between the Variational Renormalization Group and Deep Learning

Pankaj Mehta, David J. Schwab

Deep learning is a broad set of techniques that uses multiple layers of representation to automatically learn relevant features directly from structured data. Recently, such techniques have yielded record-breaking results on a diverse set of difficult machine learning tasks in computer vision, speech recognition, and natural language processing. Despite the enormous success of deep learning, relatively little is understood theoretically a... learning and compression. Here, we show... important and successful techniques in th... iterative coarse-graining scheme that allo... physical system is examined at different l...
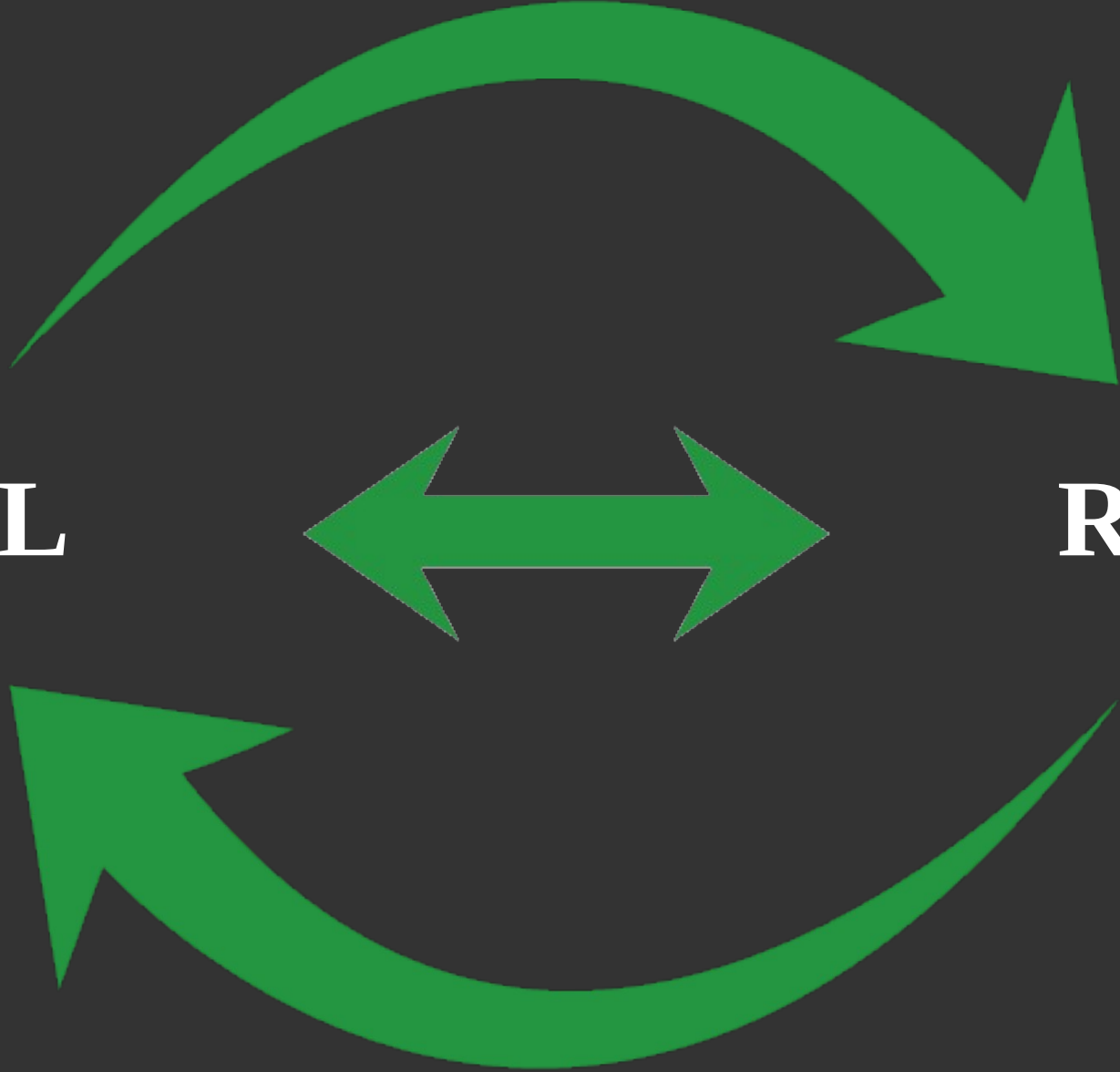
What would be the short-distance or the high-energy behavior of such a theory? Well, suppose we make a graph in coupling-constant space showing the trajectory of the coupling constants G, f, f', h, etc., as we vary the renormalization scale. The renormalization group applies here; a theory doesn't have to be renormalizable for us to apply the renormalization-group method to it. These trajectories simply describe how all the couplings change as you go from one renormalization scale to another. Now many of those trajectories—in fact, perhaps most of them—go off to infinity as you go to short-distance renormalization scales. However, it may be that there's a fixed point somewhere in coupling-constant space. A fixed point, remember, is defined by the condition that if you put the coupling constant at that point it stays there as you vary the renormalization scale. Now, it is a fairly general phenomenon that for each fixed

Weinberg, Why the Renormalization Group Is a Good Thing (1983)

Scope

ML

RG

Schedule

	Day 1	Day 2	Day 3	Day 4	Day 5
08:30 – 09:30	**Registration** — Aula Renzo Leonardi, ECT*				
09:30 – 11:00	**Opening** / **Introduction** — Aula Renzo Leonardi, ECT* (09:45 – 10:15); **Talks** — Aula Renzo Leonardi, ECT* (10:15 – 11:00)	**Talks** — Aula Renzo Leonardi, ECT* (09:30 – 11:00)	**Talks** — Aula Renzo Leonardi, ECT* (09:30 – 11:00)	**Talks** — Aula Renzo Leonardi, ECT* (09:30 – 11:00)	**Talks** — Aula Renzo Leonardi, ECT* (09:30 – 11:00)
11:00 – 11:30	**Coffee Break** — Aula Renzo Leonardi, ECT*	**Coffee Break** — Aula Renzo Leonardi, ECT*	**Coffee Break** — Aula Renzo Leonardi, ECT*	**Coffee Break** — Aula Renzo Leonardi, ECT*	**Coffee Break** — Aula Renzo Leonardi, ECT*
11:30 – 12:15	**Talks** — Aula Renzo Leonardi, ECT*	**Talks** — Aula Renzo Leonardi, ECT*	**Talks** — Aula Renzo Leonardi, ECT*	**Talks** — Aula Renzo Leonardi, ECT*	**Talks** — Aula Renzo Leonardi, ECT*
12:15 – 12:30	**Discussion**	**Discussion**	**Discussion**	**Discussion**	**Discussion**
12:30 – 14:30	**Lunch Break** — Aula Renzo Leonardi, ECT*	**Lunch Break** — Aula Renzo Leonardi, ECT*	**Lunch Break** — Aula Renzo Leonardi, ECT*	**Lunch Break** — Aula Renzo Leonardi, ECT*	**Lunch Break** — Aula Renzo Leonardi, ECT*
14:30 – 15:15	**Talks** — Aula Renzo Leonardi, ECT*	**Talks** — Aula Renzo Leonardi, ECT*	**Talks** — Aula Renzo Leonardi, ECT*	**Talks** — Aula Renzo Leonardi, ECT*	**Discussion** — Aula Renzo Leonardi, ECT*
15:15 – 15:45	**Coffee Break** — Aula Renzo Leonardi, ECT*	**Coffee Break** — Aula Renzo Leonardi, ECT*	**Coffee Break** — Aula Renzo Leonardi, ECT*	**Coffee Break** — Aula Renzo Leonardi, ECT*	**Coffee Break** — Aula Renzo Leonardi, ECT*
15:45 – 16:30	**Talks** — Aula Renzo Leonardi, ECT*	**Talks** — Aula Renzo Leonardi, ECT*	**Talks** — Aula Renzo Leonardi, ECT*	**Talks** — Aula Renzo Leonardi, ECT*	**Closing**
16:30 – 17:00	**Discussion** — Aula Renzo Leonardi, ECT*	**Discussion** — Aula Renzo Leonardi, ECT*	**Discussion** — Aula Renzo Leonardi, ECT*	**Discussion** — Aula Renzo Leonardi, ECT*	
17:30 – 18:30	**Welcome Aperitif** — Villa Tambosi, ECT*				
20:00 – 22:00				**Conference Dinner** — Ristorante Orso Grigio, Trento	

Slack