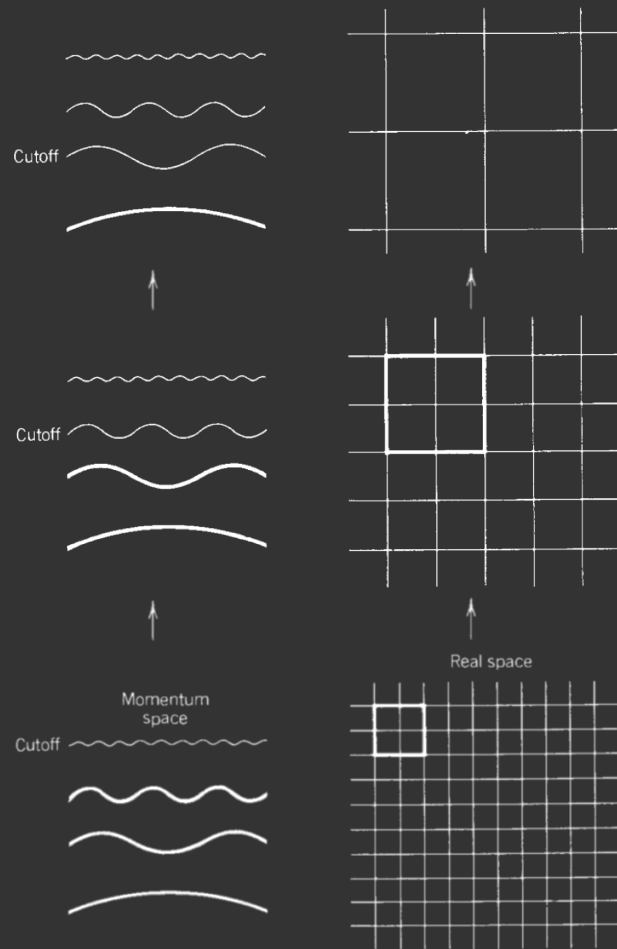
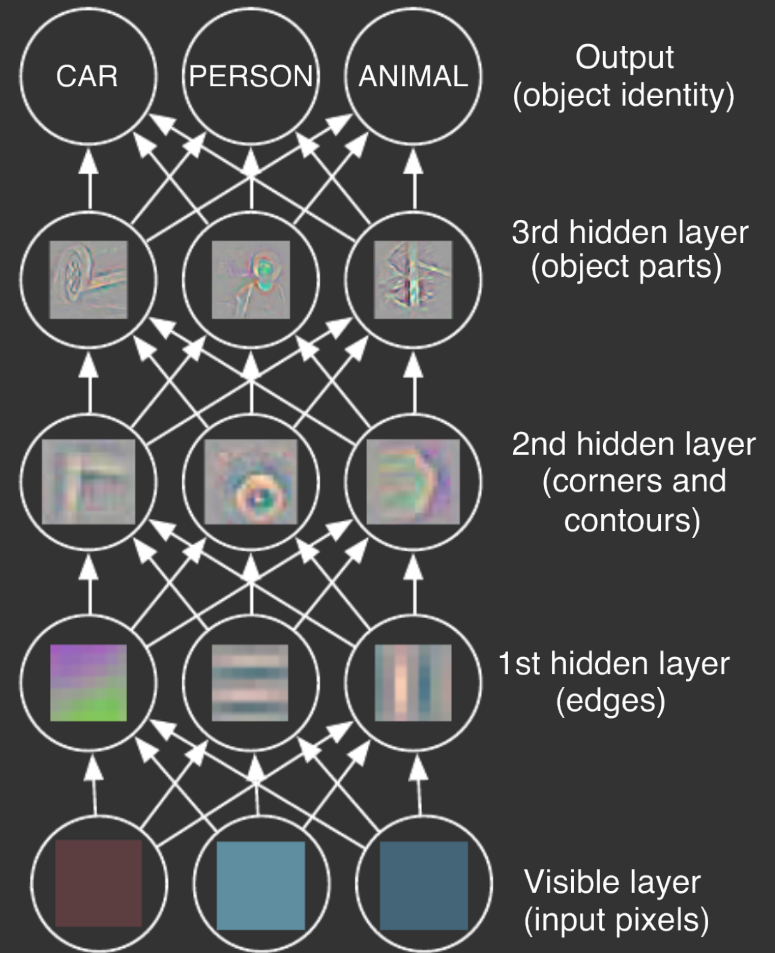
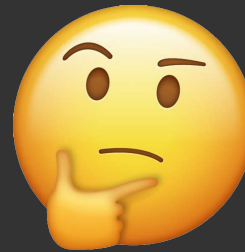


Machine Learning and the Renormalization Group



Huang, Statistical Mechanics



Goodfellow, Deep Learning

A Brief Early History of Renormalization



A Brief Early History of Renormalization

- Stueckelberg: (lost) manuscript on renormalization for QED (~1942)
- Tomonaga, Schwinger, Feynman: radiative corrections in QED (1946-48)
- Stueckelberg & Petermann: *La renormalisation des constantes 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

[Submitted on 14 Oct 2014]

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 about deep learning and compression. Here, we show how important and successful techniques in the field are related to an iterative coarse-graining scheme that allows a physical system to be examined at different length scales.

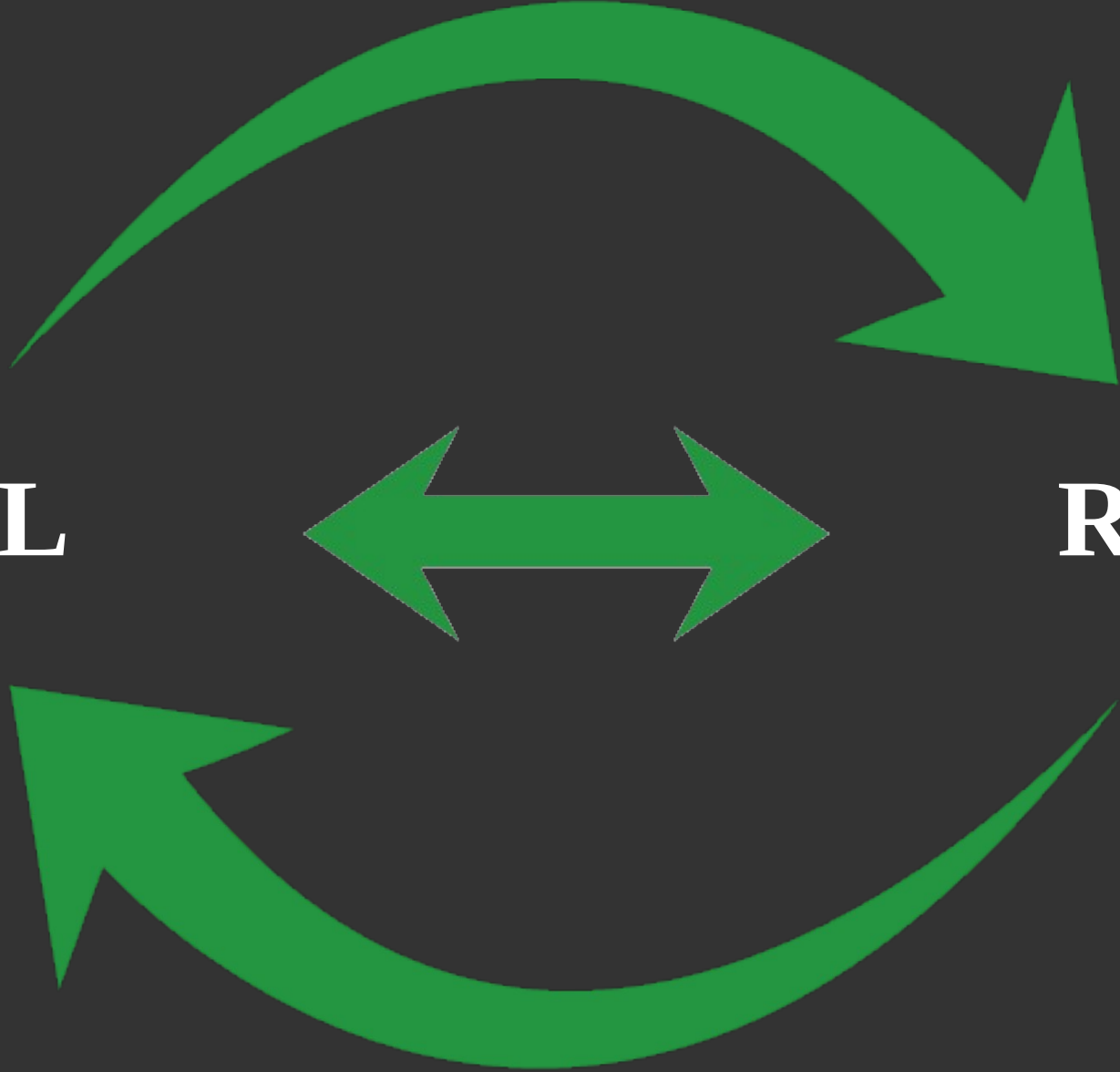
What would be the short-distance or the high-energy behavior of such a theory? Well, suppose we make a graph in coupling-constant space showing the trajectory of the coupling constants G, f, f', h , etc., as we vary the renormalization scale. The renormalization group applies here; a theory doesn't have 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

09:00	Registration			
	Aiello Renzo Leonard, ECT*	08:30 - 09:30		
	Opening		Talks	
10:00	Introduction		Talks	
	Aiello Renzo Leonard, ECT*	09:45 - 10:15		
	Talks		Talks	
	Aiello Renzo Leonard, ECT*	10:15 - 11:00	Aiello Renzo Leonard, ECT*	09:30 - 11:00
11:00	Coffee Break		Coffee Break	
	Aiello Renzo Leonard, ECT*	11:00 - 11:30	Aiello Renzo Leonard, ECT*	11:00 - 11:30
	Talks		Talks	
	Aiello Renzo Leonard, ECT*	11:30 - 12:15	Aiello Renzo Leonard, ECT*	11:30 - 12:15
12:00	Discussion		Discussion	
	Lunch Break		Lunch Break	
13:00	Talks		Talks	
	Aiello Renzo Leonard, ECT*	12:30 - 14:30	Aiello Renzo Leonard, ECT*	12:30 - 14:30
14:00	Talks		Talks	
	Aiello Renzo Leonard, ECT*	14:30 - 15:15	Aiello Renzo Leonard, ECT*	14:30 - 15:15
15:00	Coffee Break		Coffee Break	
	Aiello Renzo Leonard, ECT*	15:15 - 15:45	Aiello Renzo Leonard, ECT*	15:15 - 15:45
	Talks		Talks	
	Aiello Renzo Leonard, ECT*	15:45 - 16:30	Aiello Renzo Leonard, ECT*	15:45 - 16:30
	Discussion		Discussion	
	Aiello Renzo Leonard, ECT*	16:30 - 17:00	Aiello Renzo Leonard, ECT*	16:30 - 17:00
17:00				
18:00	Welcome Aperitif			
	Villa Tambosi, ECT*	17:30 - 18:30		
19:00				
20:00	Conference Dinner			
	Ristorante Orso Grigio, Trento	20:00 - 22:00		
21:00				
22:00				

Slack

Machine Learning and the Renormalization Group

27–31 May 2024
ECT*
Europe/Rome timezone

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Overview

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[Registration](#)

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Contact

 gazzoli@ectstar.eu

From stochastic annealing to diffusion models, the unreasonable effectiveness of physics concepts for the design of powerful machine learning algorithms has become increasingly apparent over the past two decades. Likewise, similarities between renormalization group transformations and neural networks are being explored for various applications, ranging from hierarchical models in computer vision to trivializing maps in lattice field theory. On the other hand, there has also been growing interest in the utilization of information bottleneck and quantum field theory techniques towards an improved theoretical understanding of the empirical successes of deep learning. Furthermore, exciting mathematical connections between functional renormalization group equations and optimal transport theory are being understood for the first time. This interdisciplinary workshop aims to provide an interface for experts from different fields sharing a common interest in this topic, with the goal of advancing our collective understanding and identifying promising directions for future work.

Supporting institutions

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 **Starts** 27 May 2024, 08:30
Ends 31 May 2024, 23:45
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 **ECT***
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