Pain and Machine Learning

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A Universal Feature of Human Experience

€200 billion
European Health systems

$635 billion
US Health systems
Scientific Pain
Pain studied scientifically, clinically and biologically

Folk Pain
Pain as understood amongst people in everyday experience
Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage.

—The International Association for Study of Pain (IASP)
Pain is always subjective; it is unquestionably a sensation in a part or parts of the body, but it is also always unpleasant and therefore also an emotional experience;

Biologists recognize that those stimuli which cause pain are liable to damage tissue;

Many people report pain in the absence of tissue damage or any likely pathophysiological cause and that usually this happens for psychological reasons;

and there is usually no way to distinguish their experience from that due to tissue damage if we take the subjective report.

—The International Association for Study of Pain (IASP)
Pain Eliminativism

The concept of pain fails to refer to anything empirical, so we would be better served by removing it from our usage and instead discovering other vocabularies to serve its place.
The painful sensation. Pain is not paired with any representation of a physical state or stimulus, but is seen to occur in correlation with them.
Representation Model

Pain is a representation, or abstraction, of a perceptual feature of one’s environment or body.
Motivational Model

Pain is a request or command to protect a part of your body.
Theories of perception suffer from one fundamental flaw: they are theories of vision.

—Ann-Sophie Barwich

Does this resonate with the trajectory we have taken in Machine Learning?
Think of perception as always combining multiple sources of contextual information to form final perceptual states.

Allows for painful situations
Object-less account of sensory states.
Pain as Inference

Pain is considered an active predictor of future bodily states, as well as an assessor of current afferent information, and Bayesian updating transforms multimodal prior experiences into future assessments.
Pain as Reward

General type of reward formed by integrated sensory information – general type of cumulant – used within a risk-averse intrinsic motivation system.
Pain Learning Insights

- Single-shot learning
- Single exposure learning
- Transfer learning
- Generalisability to novel pain stimuli
- Imitation learning
- Social transfer of acquired pain knowledge

Levels of Analysis for Machine Learning

Levels of Analysis for Machine Learning

- Computational
- Algorithmic
- Implementation

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ABSTRACT

Machine learning is currently involved in some of the most vigorous debates it has ever seen. Indeed, the momentum around it has led to an acceleration of research in machine learning, much to the distaste of some. As a result, we advocate for the adoption of measures such as

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Computational and Algorithmic Levels

- Noxious Stimuli (mechanical, thermal, chemical)
- Nociceptive stimulation
- Inflammatory and Bio-molecular mediators
- Dorsal horn of the spine
- Pain neuromatrix (ACC, insula, PFC, amygdala, hypothalamus, sensory cortex)

- Cognitive appraisal
- Emotional reaction
- Attention
- Behavioural response

- Descending pathway inhibition
- Ascending nociceptive pathways

Inflammatory and Bio-molecular mediators

Cognitive appraisal

Emotional reaction

Attention

Behavioural response

Pain neuromatrix (ACC, insula, PFC, amygdala, hypothalamus, sensory cortex)
Look at Pain Research

View on the world of pain research and the many dimensions it takes, whether in technical, social, or the sociotechnical domain.

Describe the Missing Level

To fill the missing algorithmic layer using situational assessment as a guide to developing new insights on learning.
And a woman spoke, saying, Tell us of Pain.

And he said:
Your pain is the breaking of the shell that encloses your understanding.
Even as the stone of the fruit must break, that its heart may stand in the sun, so must you know pain.
And could you keep your heart in wonder at the daily miracles of your life your pain would not seem less wondrous than your joy;
And you would accept the seasons of your heart, even as you have always accepted the seasons that pass over your fields.
And you would watch with serenity through the winters of your grief.

Much of your pain is self-chosen.
It is the bitter potion by which the physician within you heals your sick self.
Therefore trust the physician, and drink his remedy in silence and tranquility:
For his hand, though heavy and hard, is guided by the tender hand of the Unseen,
And the cup he brings, though it burn your lips, has been fashioned of the clay which the Potter has moistened with His own sacred tears.
Some Resources

Pain and Machine Learning

Mohammad and Daniel (2019)
Department of History and Philosophy of Science, University of Cambridge

Abstract

Throughout the history of machine learning, we have redefined our understanding of learning as humans and our ability to process information. This research explores the potential role of machine learning in pain research and its implications for understanding pain perception.

Why You Can’t Make a Computer That Feels Pain

It has seemed important to many people who believe that computers cannot in principle duplicate human feats, activities, or functions. Such aprioristic claims, we have learned, have an astonishing history of subsequent falsification. Contrary to recent theoretical optimism, for instance, computers can sometimes predict better than the average person. It is a problem for those who have naively interpreted the logic of these conclusions as indicating the feasibility of achieving human-level artificial intelligence.

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Pain: A Precision Signal for Reinforcement Learning and Control

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The pain system is a neural network that processes information about pain, including pain intensity, location, and modality. This information is then used to modulate behavior to avoid further pain and to promote healing. The pain system is composed of a variety of neuronal populations that are interconnected through a complex network of neural pathways. The pain system is also influenced by other systems, such as the autonomic nervous system and the endocrine system, which can modulate pain perception and response.

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