

Automated construction of cognitive maps with visual predictive coding

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Humans construct internal cognitive maps of their environment directly from sensory inputs without access to a system of explicit coordinates or distance measurements. Although machine learning algorithms like simultaneous localization and mapping utilize specialized inference procedures to identify visual features and construct spatial maps from visual and odometry data, the general nature of cognitive maps in the brain suggests a unified mapping algorithmic strategy that can generalize to auditory, tactile and linguistic inputs. Here we demonstrate that predictive coding provides a natural and versatile neural network algorithm for constructing spatial maps using sensory data. We introduce a framework in which an agent navigates a virtual environment while engaging in visual predictive coding using a self-attention-equipped convolutional neural network. While learning a next-image prediction task, the agent automatically constructs an internal representation of the environment that quantitatively reflects spatial distances. The internal map enables the agent to pinpoint its location relative to landmarks using only visual information. The predictive coding network generates a vectorized encoding of the environment that supports vector navigation, where individual latent space units delineate localized, overlapping neighbourhoods in the environment. Broadly, our work introduces predictive coding as a unified algorithmic framework for constructing cognitive maps that can naturally extend to the mapping of auditory, sensorimotor and linguistic inputs.

Space and time are fundamental physical structures in the natural world, and all organisms have evolved strategies for navigating space to forage, mate and escape predation^{1–3}. In humans and other mammals, the concept of a spatial or cognitive map has been postulated to underlie spatial reasoning tasks^{4–6}. A spatial map is an internal, neural representation of an animal's environment that marks the location of landmarks, food, water and shelter, which can be queried for navigation and planning. The neural algorithms underlying spatial mapping are thought to generalize to other sensory modes to provide cognitive representations of auditory and somatosensory data⁷ as well as to construct internal maps of more abstract information including concepts^{8,9}, tasks¹⁰, semantic information^{11–13} and memories¹⁴. Empirical evidence suggests that the brain uses common cognitive mapping strategies for

spatial and non-spatial sensory information so that common mapping algorithms might exist that can map and navigate over not only visual but also semantic information and logical rules inferred from experience^{15,16}. In such a paradigm, reasoning itself could be implemented as a form of navigation within a cognitive map of concepts, facts and ideas.

After the notion of a spatial or cognitive map emerged, the question of how environments are represented within the brain and how the maps can be learned from experience has been a central question in neuroscience¹⁷. Place cells in the hippocampus are neurons that are active when an animal transits through a specific location in an environment¹⁸. Grid cells in the entorhinal cortex fire in regular spatial intervals and likely track an organism's displacement in the environment^{19,20}. Yet, even with the identification of a substrate for the representation of

Construction Of Cognitive Maps

SJ Ball



Construction Of Cognitive Maps:

The Enigmatic Realm of **Construction Of Cognitive Maps**: Unleashing the Language is Inner Magic

In a fast-paced digital era where connections and knowledge intertwine, the enigmatic realm of language reveals its inherent magic. Its capacity to stir emotions, ignite contemplation, and catalyze profound transformations is nothing lacking extraordinary. Within the captivating pages of **Construction Of Cognitive Maps** a literary masterpiece penned with a renowned author, readers attempt a transformative journey, unlocking the secrets and untapped potential embedded within each word. In this evaluation, we shall explore the book's core themes, assess its distinct writing style, and delve into its lasting effect on the hearts and minds of people who partake in its reading experience.

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