

Towards Universal Parameterization: Using Variational Autoencoders to Parameterize Airfoils

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A design can only be as good as its mathematical representation. In engineering design optimization, the chosen method of parameterization can have significant impact on the outcomes. This paper introduces a novel methodology for airfoil design parameterization utilizing variational autoencoders (VAEs), a class of neural networks known for their proficiency in reducing dimensionality. However, a significant challenge with VAEs is the interpretability of the encoded latent space. This work aims to address this issue by creating a network with an interpretable latent space, yielding parameters that are understandable to humans. The effectiveness of this approach is evaluated using the comprehensive UIUC airfoil database, which offers a diverse range of airfoil shapes for analysis. We show that a VAE can successfully extract key features of airfoil geometries and parameterize them using six parameters, which show a clear correlation with airfoil properties in a way that remains understandable by the designer. Additionally, it smoothly interpolates the data points, allowing the generation of new airfoils and thus offering a practical and interpretable airfoil parameterization.

I. Nomenclature

$\vec{\cdot}$	=	Vector variable	L_{recon}	=	Reconstruction loss
$\hat{\cdot}$	=	Normalized variable	D_{KL}	=	Kullback–Leibler divergence
x	=	Input	$\mathcal{P}$	=	Airfoil property values
x'	=	Reconstructed input or generated output	δ	=	Value range
Z	=	Latent parameter	w	=	Correlation coefficient weights
n	=	Number of latent parameters	t_{max}	=	Maximum thickness
μ	=	Mean	x_{tmax}	=	Chordwise max thickness location
σ	=	Standard Deviation	c_{max}	=	Maximum camber
$\mathcal{N}(\mu, \sigma)$	=	Gaussian distribution	x_{cmax}	=	Chordwise max camber location
$\mathcal{U}(a, b)$	=	Uniform distribution in range $[a, b]$	R_{LE}	=	Leading edge radius
ϵ	=	Random value	θ_{LE}	=	Leading edge angle
β	=	Weight factor for KL divergence	θ_{TE}	=	Trailing edge angle
i, j	=	Latent parameter index	γ_{TE}	=	Trailing edge wedge angle
L_{train}	=	Training loss			

II. Introduction

The rise of neural network technologies in various domains, including aerospace engineering, has introduced new methods and opportunities for engineering design. Neural networks are particularly valued for their universal function approximation capabilities [1], which can be used to uncover hidden patterns within datasets. However, a major issue with these networks is their lack of interpretability, due to the complexity of their internal processes. This problem, often referred to as the “black box” issue, limits their use in practical design scenarios where understanding the influence of design parameters on design performance is crucial.

This study aims to leverage the function approximation capabilities of neural networks to assess the potential of generative networks in providing a universally applicable, automated approach to parameterization. This involves

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The Parameterization Of Universal Grammar Linguistik Aktuell Vol 8

Rose Arny



The Parameterization Of Universal Grammar Linguistok Aktuell Vol 8:

The Parametrization of Universal Grammar Gisbert Fanselow, 1993-02-25 In this volume the subject of parametrization is addressed from various though interrelated perspectives ranging from learnability the form and nature of parametrization the role of the interface between morphology and syntax and the parameters of X bar syntax to the lexical parametrization hypothesis **From Syntax to Discourse** C. Hamann, 2012-12-06 claim is that such morphological processes can be learnt without symbolization and innate knowledge See Rumelhart and McClelland 1986 for the original model of past tense acquisition Plunkett and Marchman 1993 Nakisa Plunkett and Hahn 1996 and Elman et al 1996 for developments and extensions to other morphological processes and Marcus et al 1992 and Pinker and Prince 1988 for criticism One line of investigation supporting the view of language as a genetic endowment is closely linked to traditional research on language acquisition and argues as follows If language is innate there must be phenomena that should be accessible from birth in one form or the other Thus it is clear that the language of children especially young children and preferably babies should be investigated As babies unfortunately don't talk the abilities that are available from birth must be established in ways different from the usual linguistic analysis Psycholinguistic research of the last few years has shown that at the age of 4 and 8 months and even during their first week of life children already have important language skills From the fourth day infants distinguish their mother tongue from other languages From the first months children prefer the sound of speech to other noise At the age of 4 months infants prefer pauses at syntactic boundaries to random pauses The Development of Chomskyan Generative Grammar Mei Deming, Tong Helong, 2024-06-28 This book explores the major theories of generative grammar from a historical perspective providing an overview of the evolution of this linguistic framework Generative grammar is widely recognized for its major contributions to the study of theoretical linguistics in the twentieth century and has had a profound impact on the fields of linguistics psychology computer science and cognitive science This book consists of eight chapters that trace the development of generative grammar from its beginnings to its current focus on minimalism The first chapter outlines the major stages of generative grammar namely Classical Theory Standard Theory Extended Standard Theory Revised Extended Standard Theory Government and Binding Theory and the Minimalist Program The second chapter reviews the development of the C command relation and illustrates its use in syntactic analysis Each of the following six chapters focuses on a specific area of generative grammar including phrase structure movement Case argument structure binding and raising and control The volume will be an invaluable resource for researchers teachers and students in the fields of generative grammar syntax formal linguistics and the social and cognitive sciences Brinkman's catalogus van boeken en tijdschriften, 1996 With 1901 1910 1956 1960 Repertorium is bound Brinkman's Titel catalogus van de gedurende 1901 1910 1956 1960 Title varies slightly **Bibliografie van de Nederlandse taal- en literatuurwetenschap**, 1996

The Syntax of the Sentence in Old Irish Pádraig MacCoisdealbha, 2012-10-29 Old Irish is the language of Ireland in

the period from the 8th to the 10th century AD and is the oldest Celtic language well enough attested for adequate grammatical study The book provides the only available detailed linguistic analysis of the syntactic structure of the Old Irish sentence The basic form of the simple sentence with the usual order of elements verb subject object is unproblematic from a synchronic viewpoint but certain sentence types show more complex patterns of syntax which have important implications for the typological diachronic and comparative historical analysis of Old Irish in particular and Celtic and Indo European languages in general Sentence types which contain obligatory cataphoric pronouns referring to elements later in the same sentence are examined in detail as well as constructions with marked initial topics and the focussing construction of the cleft sentence The approach is functional and typological on the basis of a text corpus from the glosses on the Pauline epistles at W rzburg with further material from Old Irish legal texts The emphasis is on the communicative content and intent of the sentences of the corpus The book is a newly edited version of MacCoisdealbha s Bochum dissertation of 1974 previously unpublished due to the author s death in 1976 and includes textual notes by the editor indicating progress and indeed lack of progress in the meantime in areas covered by the book

Models of Inflection Ray Fabri,Albert Ortmann,Teresa Parodi,2013-02-06 The aim of the volume is to contribute towards a better understanding of inflectional morphology as well as to provide a platform for researchers to discuss their results in the light of the particular framework they have chosen to work in The first paper provides an overview of the main controversies within the area of inflection Other papers deal with general aspects such as the difference between derivation and inflection irregular verb inflection animacy and clitics These are followed by studies on functional categories the acquisition of inflection a formal implementation of Russian verb inflection and finally articles that deal specifically with aspects of German inflection

From NP to DP Martine Coene,Yves D[hulst,2003-07-17 This is the first of a two volume selection of refereed and revised papers originally presented at the international conference From NP to DP at the University of Antwerp The papers address issues in the syntax and semantics of the noun phrase in particular the so called DP hypothesis which takes noun phrases to be headed by a functional head D eterminer The major concerns can be grouped around 3 subthemes the internal syntax of noun phrases the syntax and semantics of bare nouns and indefinites and the expression of measurement in noun phrases The wealth of data coming from over 40 different languages combined with a thorough introduction to the current issues in the field of NPs DPs and some alternative syntactic and semantic analyses provide a comprehensive reference work from both a descriptive and a theoretical point of view The second volume is concerned exclusively with the expression of possession in noun phrases

Structuring Variation in Romance Linguistics and Beyond Mirko Grimaldi,Rosangela Lai,Ludovico Franco,Benedetta Baldi,2018-12-15 Current theoretical approaches to language devote great attention to macro and micro variation and show an ever increasing interest in minority languages In this respect few empirical domains are as rich and lively as the Italo Romance languages which together with Albanian were the main research domain of Leonardo M Savoia

The volume covers areas as different as phonology morphology syntax and the lexicon A broad range of Romance languages is considered as well as Albanian Greek and Hungarian shedding new light on many classical topics The first section focuses on morphosyntax both in the narrow sense and with regard to its interfaces The second section focuses on clitics and pronouns The third section deals with a number of issues in phonology and syntax phonology interface The last section turns the reader's attention beyond formal linguistics itself and examines variation in the light of neurosciences pathology historical linguistics and political discourse

Language, 1995 Satzstruktur und Verbbewegung Claudia Maria Schmidt, 1995 Das minimalistische Programm von Chomsky 1993 reduziert das Prinzipien und Parametermodell der generativen Grammatik auf die minimal notwendigen Bestandteile Kaynes 1993 Antisymmetrietheorie der Phrasenstruktur führt in diesem Sinne die hierarchische Gliederung von Phrasen und Sätzen auf die Erfordernis zur sprachliche Ausdrücke in der Zeit zu linearisieren Dies bringt eine Reihe empirisch fundierter Neuerungen in allen Bereichen des Grammatikmodells mit sich Repräsentationsebenen mögliche Phrasenstrukturen die Lokalisation syntaktischer Prozesse und Parameterformate Diese empirischen Voraussagen werden im ersten Teil der Untersuchung auf einen strukturell definierten Teilbereich des deutschen Satzes fokussiert auf den der IP entspricht im Feldermodell dem Bereich von Mittelfeld bis Nachfeld im zweiten Teil berprft und dabei groenteils besttigt wodurch sich neuartige Analysen für Verbendstellung verbales Passiv Extraposition und die variable Stellung von nominalen Satzgliedern im Mittelfeld Scrambling ergeben Indem einige neue funktionale syntaktische Kategorien und eine Modifikation des minimalistischen Lokalkonzepts der Quiddistanz eingeführt werden folgt die Phrasenstruktur in einer Einzelsprache hier exemplifiziert durch die IP im Deutschen aus wenigen sprachunspezifisch formulierbaren grammatischen Prinzipien und Parametern die nur das finite sprachspezifische Vokabular syntaktischer Merkmale lexikalischer Kategorien verwenden

Forthcoming Books Rose Arny, 2003 **Linguistics and Language Behavior Abstracts**, 1998 **Romanistische Syntax - minimalistisch** Eva-Maria Remberger, Guido Mensching, 2008 **BLL**, 1993 *Boekblad*, 1993 *Polski Biuletyn Semiotyczny*, 1991 **American Book Publishing Record**, 1997 **Linguisticae investigationes**, 1993 *Aslib Proceedings*, 1969

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