Simplicial Calculus with Geometric Algebra

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ABSTRACT. We construct geometric calculus on an oriented k-surface embedded in Euclidean space by utilizing the notion of an oriented k-surface as the limit set of a sequence of k-chains. This method provides insight into the relationship between the vector derivative, and the Fundamental Theorem of Calculus and Residue Theorem It should be of practical value in numerical finite difference calculations with integral and differential equations in Clifford algebra.

0. Introduction

In 1968, D. Hestenes showed how Geometric Algebra can be used to advantage in reformulating ideas from multivariable calculus [1], [2]. For example, he showed that the proof of Stokes' theorem becomes a one–line identity in geometric algebra, if the integral definition of the vector derivative is adopted. In this paper, we systematically build up calculus on a k-surface in order to more closely examine the content of these theorems.

Section 1 gives a brief introduction to the geometric algebra of Euclidean n-space, including basic definitions and identities which are be used in later sections. The inner, outer, and geometric products of vectors are discussed, as is the notion of a reciprocal frame of vectors. The material in this section is taken from [3], [4], and, primarily [5].

In section 2 the concept of an oriented simplex is introduced and related notions from homology theory are reviewed; more details can be found in [6], [7]. Peculiar to the present approach are the concepts of the *directed* content of a simplex, made possible by the introduction of geometric algebra, and the *simplicial variable* of a k-surface. These concepts are the basic building blocks for our theory of simplicial calculus developed in later sections.

In section 3 a k-surface is defined to be the limit set of an appropriate sequence of chains of simplices. A k-surface φ is said to be *smooth* *if there exists* a smooth k-vector field, called the *pseudoscalar field*, at each point of φ. Our approach is most closely related to [8].

In section 4 the *directed integral* on a k-surface is defined in terms of the directed content of the limit of the sequence of chains which defines it. The theory of directed integrals is first developed over a k-simplex, and then generalized. The most remarkable theorem of this section, which has no counterpart in the related theory of scalar-valued differential forms, expresses the *directed moment* of the boundary of a k-simplex as the inner product of the directed content of the simplex with the direction of the axis.

In section 5 the vector derivative is defined in terms of the limit of the directed integral over the boundary of the simplicial variable as this variable approaches zero. The vec-

Simplicial Calculus With Geometric Algebra

Thomas Griffiths

Simplicial Calculus With Geometric Algebra:

Clifford Algebras and their Applications in Mathematical Physics A. Micali,R. Boudet,J. Helmstetter,2013-03-09 This volume contains selected papers presented at the Second Workshop on Clifford Algebras and their Applications in Mathematical Physics These papers range from various algebraic and analytic aspects of Clifford algebras to applications in for example gauge fields relativity theory supersymmetry and supergravity and condensed phase physics Included is a biography and list of publications of M rio Schenberg who next to Marcel Riesz has made valuable contributions to these topics This volume will be of interest to mathematicians working in the fields of algebra geometry or special functions to physicists working on quantum mechanics or supersymmetry and to historians of mathematical physics **Advances in Chemical Physics, Volume 125** Ilya Prigogine,Stuart A. Rice,2003-01-31 Advances in Chemical Physics covers recent advances at the cutting edge of research relative to chemical physics The series Advances in Chemical Physics provides a forum for critical authoritative evaluations of advances in every area of the discipline **Quaternionic and Clifford Calculus for Physicists and Engineers** Klaus Gürlebeck,Wolfgang Sprössig,1997 Quarternionic calculus covers a branch of mathematics which uses computational techniques to help solve problems from a wide variety of physical systems which are mathematically modelled in 3 4 or more dimensions Examples of the application areas include thermodynamics hydrodynamics geophysics and structural mechanics Focusing on the Clifford algebra approach the authors have drawn together the research into quarternionic calculus to provide the non expert or research student with an accessible introduction to the subject This book fills the gap between the theoretical representations and the requirements of the user

Clifford Algebra to Geometric Calculus David Hestenes,Garret Sobczyk,1987-08-31 Matrix algebra has been called the arithmetic of higher mathematics Be We think the basis for a better arithmetic has long been available but its versatility has hardly been appreciated and it has not yet been integrated into the mainstream of mathematics We refer to the system commonly called Clifford Algebra though we prefer the name Geometric Algebm suggested by Clifford himself Many distinct algebraic systems have been adapted or developed to express geometric relations and describe geometric structures Especially notable are those algebras which have been used for this purpose in physics in particular the system of complex numbers the quatemions matrix algebra vector tensor and spinor algebras and the algebra of differential forms Each of these geometric algebras has some significant advantage over the others in certain applications so no one of them provides an adequate algebraic structure for all purposes of geometry and physics At the same time the algebras overlap considerably so they provide several different mathematical representations for individual geometrical or physical ideas Mathematical Reviews ,2005 Abstracts of Papers Presented to the American Mathematical Society American Mathematical Society,1998 **The ... Catalogue of the State University of Iowa** State University of Iowa,1966 *Calculus of Fractions and Homotopy Theory* Peter Gabriel,M. Zisman,2012-12-06 The main purpose of the present work is to present to

the reader a particularly nice category for the study of homotopy namely the homo topic category IV This category is in fact according to Chapter VII and a well known theorem of J H C WHITEHEAD equivalent to the category of CW complexes modulo homotopy i e the category whose objects are spaces of the homotopy type of a CW complex and whose morphisms are homotopy classes of continuous mappings between such spaces It is also equivalent I 1 3 to a category of fractions of the category of topological spaces modulo homotopy and to the category of Kan complexes modulo homotopy IV In order to define our homotopic category it appears useful to follow as closely as possible methods which have proved efficacious in homo logical algebra Our category is thus the topological analogue of the derived category of an abelian category VERDIER The algebraic machinery upon which this work is essentially based includes the usual grounding in category theory summarized in the Dictionary and the theory of categories of fractions which forms the subject of the first chapter of the book The merely topological machinery reduces to a few properties of Kelley spaces Chapters I and III The starting point of our study is the category 10 Iff of simplicial sets C S S complexes or semi simplicial sets in a former terminology *Journal of Physics A* ,1999 Focuses on fundamental mathematical and computational methods underpinning physics Relevant to statistical physics chaotic and complex systems classical and quantum mechanics classical and quantum integrable systems and classical and quantum field theory **Bulletin (new Series) of the American Mathematical Society** ,1980

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