

GEOMETRIC ALGEBRA - A COMPUTER SCIENCE APPROACH

Independent Reading Course - Summer 2016

Coordinator:	Arman Shamsgovara	Time:	(Prel.) 8-12 M-W-F
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Course Repository: TBA

References: This list might be extended prior to course start, but the first reference mentioned will constitute the main source of knowledge. Other than the below, research articles may be used.

- Dorst, Leo, Daniel Fontijne, and Stephen Mann. Geometric algebra for computer science: an object-oriented approach to geometry. Morgan Kaufmann Publishers Inc., 2009.

Objectives: This informal reading course is primarily intended to lie at the masters or PhD level, and will introduce the audience to the mathematical theory of geometric algebra. We will try to discuss the theory from two main perspectives, a mathematical standpoint and a more computer science - oriented approach. We will focus on a mix between pure theory and practical implementation of said theory. At the end of the course, a successful student should:

- Have a thorough understanding of basic notions of geometric algebra,
- Have an understanding of how geometric algebra may be used in mathematics and computer science,
- Be able to present some of the more basic results regarding geometric algebra,
- Be able to prove some of the more basic results regarding geometric algebra,
- Be able to solve basic and intermediate problems involving geometric algebra,
- Be able to implement algorithms / programs using geometric algebra,
- Have achieved enough insight in geometric algebra and its applications to be able to pursue further studies and/or research in the topic or surrounding such.

Prerequisites: First and foremost, mathematical maturity and a willingness to learn are essential to participate. Undergraduate linear algebra is assumed, and a must in order to be able to gain anything from the course, but will be briefly repeated at the start of the course to synchronize the knowledge of all participants. Undergraduate knowledge of data structures and algorithms is a bare minimum prerequisite for the computer science - related parts. For applications, familiarity with computer graphics and working with the library OpenGL will be an advantage, as will experience with robotics, but not necessary.

Tentative Course Outline: We will follow the book by Dorst et al, but may make detours in which we dive into articles along the ride. Implementation of basic routines illustrating the theory are likely to occur. The book by Dorst et al is divided into three main parts - the mathematics of geometric algebra (I), models of geometry using said algebra (II), and implementation (III) - the course will follow suit in its design. The list below gives a crude overview of what topics are to be expected:

- Recap of necessary concepts from linear algebra, intro to course (ch.1)
- I - Oriented subspaces (ch.2)
- I - Metric products of subspaces (ch. 3)
- I - Linear transformations of subspaces (ch.4)
- I - Intersection and union of subspaces (ch.5)
- I - The fundamental product of geometric algebra (ch.6)
- I - Orthogonal transformations as versors (ch.7)
- I - Geometric differentiation (ch.8)
- II - The vector space model (ch.9-10)
- II - The homogeneous model and applications (ch.11-12)
- II - The conformal model: Euclid redux (ch.13-14-15)
- II - Conformal operators (ch.16-17)
- III - General implementation issues (ch.18)
- III - Usage of basis blades and operations (ch.19)
- III - Implementing linear products and operations (ch.20)
- III - Fundamental algorithms for nonlinear products (ch.21)
- III - Efficient implementation of geometric algebra (ch.22)
- III - Example applications (ch.23)
- Specialized topics after the participants' wishes

Course Policy:

- Course literature will mostly be presented in a lecture format, since the book will be available to one person during the course. Workshops regarding implementation will most likely occur.
- The presented material should be jointly summarized and illustrated by the entire group in a concluding set of lecture notes that will be distributed to all participants after the course. This will be extra important in this course, as the main literature is not freely (in a legal manner, at least) available to most participants.
- Voluntary exercises from the book will be presented for anyone to solve, and more importantly present in front of the class.
- Slight emphasis will be put on trying to come up with exercises, problems and/or implementations involving the topic, and summarizing these in a separate problem collection.
- The preferred language during sessions will be Swedish, while English may be more suitable for the written activities such as the note writing.
- Actual course content may deviate from what is stated in the outline, depending on how the schedule turns out.

Participation Policy:

- As this is an informal, independent student-organized reading course, it will be assumed that all participants are participating out of interest in learning the material, and are willing to cooperate in order to help everyone learn, hence excessive absence is kindly advised against, for the sake of continuity.
- The actual course schedule is subject to be set and change according to the participants' schedules and wishes. Note however, that the expected schedule covers work equivalent to at least 18 three-to-four-hour sessions split over 4 to 5 weeks, with independent reading and problem solving in between sessions.
- In case of a missed session (due to illness, work, re-exam studies or other reasons), please contact the coordinator in order for him to make any adaptations to the current schedule if so deemed necessary.
- This is an informal, independent student-organized reading course, and may as such in no way whatsoever be included in any formal educational degree of any form, regardless of what any other party says about this matter.

Important Dates:

Course Start Early July, 2016 (prel.)
Course End Late July - Early August, 2016 (prel.)

Application: Send the course coordinator an email or a direct message on CS Slack, explaining your interest in participating. State any relevant prerequisite knowledge, cf. the above list. Also state any particular wishes regarding the schedule as soon as possible. Any questions regarding the course should be directed to the course coordinator.

A Hearty Welcome To All Interested Participants!