SJSU SAN JOSÉ STATE UNIVERSITY
Department of Mathematics and Statistics

Math 297A Cover Page

Last Name: Cavallaro

Student ID Number: 008089835

First Name: Jeffery

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Degree Program: MS Mathematics

How are you fulfilling the GWAR requirement? Math-100W

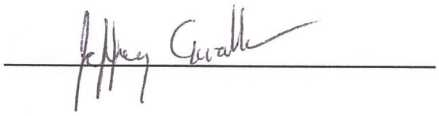
When are you planning to graduate? June 2019

List courses you need to complete your degree
All course work completed

Create your application packet which consists of the following:

- This cover page
- A title and a 1-2 page abstract/description of the project including a rough timeline for project milestones and reading list for the semester.
- Unofficial SJSU transcript and other graduate level transcripts

Submit the application packet to your thesis/project advisor in pdf format.

Student Signature 

Date 1/22/2019

k-Coloring Algorithms for Additive Manufacturing

Jeffery Cavallaro

22 January 2019

Abstract

In traditional manufacturing, parts are designed and manufactured separately so that the parts can be combined into subassemblies, which are then combined into final assemblies. Indeed, the standardization of parts was one of the key developments that fueled the explosive growth of manufacturing during the 19^{th} and 20^{th} centuries. Now, in the 21^{st} century, a new technique, referred to as *additive manufacturing*, promises a new leap in manufacturing capability: instead of manufacturing the parts for subassemblies separately, the subassemblies are constructed directly through the additive application of layers of material, commonly referred to as *3-D printing*.

But what is the best way to allocate parts into subassemblies in order to minimize the number of subassemblies? One possible answer is to represent the problem by a graph, where the nodes are the parts and the edges represent the need to separate incident parts into different subassemblies. The answer then becomes the solution to a standard proper coloring problem. So what is needed is a rationale for determining the presence of an edge. A good way to determine the separation of two parts into different subassemblies is through the use of so-called *axiomatic design*, where a set of *design parameters* (DPs) are translated into a set of *functional requirements* (FRs) via a *design matrix* (A) of common and problem-specific axioms: $[FR] = [A][DP]$.

The primary goal of this research project is to study and improve upon existing algorithms related to the k-coloring of graphs related to additive manufacturing that are obtained using the principles of axiomatic design. Since previous work has relied on manual execution of the algorithms under study, an additional goal is to develop software solutions that can extend the ability to try and compare various examples.

Timeline

Note: Some tasks to run concurrently.

Topic	weeks
Reading on Axiomatic Design	3
Reading on Additive Manufacturing	2
Reading on k-Colorable Determination Algorithms	2
Reading on Proper Coloring Algorithms	1
Existing Algorithm Analysis	2
Algorithm Improvement	4
Algorithm Software Development	2
Published Paper Support	4

Reading List

[1] G. Agnarsson and R. Greenlaw, *Graph theory: Modeling, applications, and algorithms*, Prentice Hall, Upper Saddle River, NJ, 2007.

[2] S. Behdad, P.K. Gopalakrishnan, S. Jahanbekam, and H. Kain, *Graph partitioning technique to identify physically integrated design concepts*, Proceedings of the ASME 2018 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference (2018), no. DETC2018-85646, 1–13.

[3] R. Beigel and D. Eppstein, *3-coloring in time* $\mathcal{O}(1.3289^n)$, Journal of Algorithms **54** (2005), 168–204.

[4] D. Chartrand and P. Zhang, *A first course in graph theory*, Dover Publications, Inc., Mineola, NY, 2012.

[5] R.C. Reed (ed.), *Graph theory and computing*, Academic Press, New York and London, 1972.

[6] C. Smyth, *Functional design for 3d printing*, third revised ed., 2017.

[7] N.P. Suh, *Axiomatic design theory for systems*, Research in Engineering Design **10** (1998), no. 4, 189–209.

[8] D.B. West, *Introduction to graph theory*, 2^{nd} ed., Prentice Hall, Upper Saddle River, NJ, 2001.

SJSU SAN JOSÉ STATE UNIVERSITY

Petition for Advancement to Graduate Candidacy

09.2016

Student Information

Completed form should be emailed to the appropriate GAPE evaluator (see www.sjsu.edu/gape/about_us/staff), submitted to Window G in the Student Services Center, or sent through interoffice mail to extended zip 0017.

Last Name Cavallaro First Name Jeffery

Student ID 009089835 Previous Name (if any)

Current Address 39712 Almaden Place City Fremont State CA Zip 94536

Daytime Phone 510-797-7712 Email Address jeffery.cavallaro@sjsu.edu

Degree Information

Degree Sought, *e.g.*, MBA MA Major Mathematics Concentration, if applicable

Means of satisfying Graduation Writing Assessment Requirement: Course Prefix, Catalog No. Math 100W

University where taken SJSU Semester/Year GWAR Completed Fall/2013 Plan (X) A ( ) B ( ) C

Proposed Graduate Degree Program

A. Courses (include all SJSU courses taken and those that will be taken for degree credit; leave Grade section blank for current and future classes.)

Course Prefix/No.	Title	Semester Units	Grade	Semester/Year Completed
Math 179	Intro to Graph Theory	3	A	Spring/2015
Math 279A	Graph Theory	3	A-	Fall/2015
Math 231A	Real Analysis	3	A	Spring/2016
Math 279B	Advanced Graph Theory	3	A	Spring/2016
Math 221A	Higher Algebra I	3	A+	Fall/2016
Math 238	Advanced Complex Variables	3	A+	Fall/2016
Math 221B	Higher Algebra II	3	A+	Spring/2017
Math 229	Advanced Matrix Theory	3	A-	Spring/2017
Math 231B	Functional Analysis	3	A	Fall/2017
Math 297A	Preparation for Thesis	3		Spring/2019

B. Culminating Experience

Check box if applicable and then fill out corresponding row

	Course Prefix/Catalog No. (*e.g.*, MAS 203)	Total Units	Grade	Semester/Year Completed
(X) 299 Thesis (Plan A)/Creative Work (Plan C)	Math 299	3		Fall/2019
( ) Last completed project or comprehensive exam-preparation course (plan B)				

( ) Other Culminating Experiences

	Type	Semester/Year Completed
1) Other culminating experience		
2) Other culminating experience		

( ) 599 Dissertation

Course Prefix/Catalog No. (*e.g.*, MAS 203)	Total Units	Grade	Semester/Year Completed

C. Transfer Courses

University	Course Prefix/No.	Title	Semester Units	Grade	Semester/Year Completed
Sub. for SJSU Course					
Sub. for SJSU Course					
Sub. for SJSU Course					

Units	
A	
B	
C	
Total	

Required Signatures

Student Jeffery Cavallaro Date 1/21/2019 For Official Use Only

Signature (certifies accuracy of the information provided)

The signatures below indicate approval.

Project or Thesis Advisor (if required by your department)

Name Signature Date

Department Grad Advisor (Grad Coordinator)

Name Signature Date

GAPE Evaluator

( ) Approved ( ) Denied Name Date