The Deutsch Institute of Computer Science

Bi-Annual Scientific Report
Board of Governors Meeting

May 2000

Report by the Deutsch Institute Management Committee

Chapter 1

The Deutsch Institute

1.1 History and Mission

The Deutsch Institute of Computer Science was founded through the generosity of the Deutsch family of Buenos Aires, Argentina.

The Deutsch Institute of Computer Science supports state-of-the-art research in Computer Science, performed at Tel-Aviv University, and presented at the most prestigious International Computer Science symposia. One important goal of the institute is to encourage graduate students to attend important international conferences and to present their results there. This is done by offering graduate students support to attend scientific conferences at which they present papers, in some cases support will also be given to attend workshops and summer schools.

The Deutsch Institute feels that enabling graduate students to attend international conferences and schools is perhaps the most significant contribution that one can make to further the twin goals of research and education. In the same spirit of encouraging collaboration and promoting graduate student research, the Deutsch institute also supports graduate student seminars here at Tel Aviv University.

In addition, as of the year 2000, an annual Deutsch prize in computer science will be given to a graduate student whose research was judged to be extraordinary during the previous year. The recipient of the Deutsch prize for the year 2000 is Ms. Vera Asodi.

Officers of the Deutsch Institute are Professor Hanoch Levy, Chair of the department of Computer Science and Head of the Deutsch Institute (ex officio), Professors Amos Fiat and Haim Wolfson, who are in charge of Deutsch Institute foundation support requests, and Professor Nachum Dershowitz who heads the Deutsch prize committee.

1.2 Comments by the Head of the School

The following comments are those of Professor Noga Alon, head of the School of Mathematical Sciences, Tel Aviv University:

> It is hard to overestimate the significance of the Deutsch Institute of Computer Science to the research activity in the school. The Institute supported state of the art research in Computer Science which was presented at most of the prestigious CS conferences.
> Research collaboration and exchange of ideas are the most fruitful ways to conduct research in Computer Science, and it is therefore essential that the Deutsch Institute encouraged graduate students to participate in the main conferences in Computer Science, present their research results and discuss them and other projects with prominent researchers in the world.
> The collection of selected abstracts of papers supported by the Institute, which is enclosed below, demonstrates its impact. I am convinced it will keep being a crucial Institute for supporting research in Computer Science, and it is a great pleasure to thank the Deutsch family for their donation.

1.3 Comments by the Chair

The following comments are those of Professor Hanoch Levy, chair of the Department of Computer Science and head of the Deutsch Institute:

> I was very happy to have been asked to write about the contribution of the Deutsch Institute of Computer Science to the research activity in the Department of Computer Science.
> The Deutsch Institute has focused its activity on promoting research interaction and collaboration among the youngest of our researchers, namely our graduate students. This has been done both by supporting the participation of our graduate students in the important international Computer Science conferences and by supporting internal research meetings of our students. In both ways it recognized that perhaps the best fertilizer for advanced research is the exchange of ideas among researchers. Further, it recognized that this fertilization process must start at the young generation.
> The selected abstracts enclosed below represent the research that was supported by the Deutsch institute and are an evidence to the contribution of this research to Computer Science. I trust the institute will continue having its impact on promoting excellent Computer Science research. Lastly, it is a great pleasure for me to have this opportunity to thank the Deutsch family for their donation to the institute.

Chapter 2

Research Support

2.1 Students Supported

Table 1 below lists all students supported by the Deutsch Institute. Some of these students have presented several papers with the support of the institute. Unfortunately, due to budgetary constraints, not all worthwhile research papers could have been supported.

Amnon Aden	Nadav Aleh	Ofer Arieli	Vera Asodi	Jackie Assa
Adi Avidor	Anat Bremler	Gal CheChik	Yossi Cohen	Irit Dinur
Nurit Dor	Alon Efrat	Leah Epstein	Oded Eran	Eyal Flato
Shachar Fleishman	Tzipi Fligleman	Eran Halperin	Sariel Har Peled	Guy Kindler
Vladi Koltun	Tal Lev Ami	Haim Lindrat	Ran Lotenberg	Yair Mann
Manor Mendel	Efri Nattel	Zohar Naor	Chami Navoni	Michael Nertes
Itzik Peer	Yaacov Perski	Oded Regev	Ophir Remez	Ran Saham
Roni Shapira	Roded Sharan	Omer Shibolet	Shachar Smorodinsky	Alecsandra Solan
Gideon Stupp	Gadi Wolfman	Eyal Zadicario		

Table 1: Research Students Supported by the Deutsch Institute

2.2 Selected Research Papers

On the following pages we give a selected collection of abstracts of papers supported by the Deutsch Institute.

Nonmonotonic and Paraconsistent Reasoning:
From Basic Entailments to Plausible Relations

Ofer Arieli[†]and Arnon Avron [‡]

Abstract

In this paper we develop frameworks for logical systems which are able to reflect not only nonmonotonic patterns of reasoning, but also paraconsistent reasoning. For this we consider a sequence of generalizations of the pioneering works of Gabbay, Kraus, Lehmann, Magidor and Makinson. Our sequence of frameworks culminates in what we call plausible, nonmonotonic, multiple-conclusion consequence relations (which are based on a given monotonic one). Our study yields intuitive justifications for conditions that have been proposed in previous frameworks, and also clarifies the connections among some of these systems. In addition, we present a general method for constructing plausible nonmonotonic relations. This method is based on a multiple-valued semantics, and on Shoham's idea of preferential models.

Presented at the 5th European Conference on Symbolic and Quantitative Approaches to Reasoning with Uncertainty (ecsqaru'99). London, UK, July 5-9 1999. Lecture Notes in Computer Science No. 1638, pages 11-22, Springer, 1999.

[†] *Supported by the Deutsch Institute*
[‡]Dept. of Computer Science, Tel Aviv University, Tel Aviv, Israel

Sparse Universal Graphs for General Max-degree 3 Graphs

Noga Alon† Vera Asodi‡

Abstract

For every n, we describe an explicit construction of a graph on n vertices with at most $O(n^{2-\epsilon})$ edges, for $\epsilon = 0.133\ldots$, that contains every graph on n vertices with maximum degree 3 as a subgraph. The construction is explicit, but the proof of its properties is based on probabilistic arguments. It is easy to see that each such graph has $\Omega(n^{\frac{4}{3}})$ edges. The study of this problem is motivated by questions in VLSI circuit design.

Vera Asodi was awarded the Deutsch Prize for the year 2000 in recognition of her research.

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†Department of Mathematics, Raymond and Beverly Sackler Faculty of Exact Sciences, Tel Aviv University, Tel Aviv, Israel. Research supported in part by a USA-Israeli BSF grant, by the Israel Science Foundation and by the Hermann Minkowski Minerva Center for Geometry at Tel Aviv University. Email: noga@math.tau.ac.il.
‡ Department of Computer Science, Raymond and Beverly Sackler Faculty of Exact Sciences, Tel Aviv University, Tel Aviv, Israel. Email: vera@math.tau.ac.il. Research supported by the Deutsch Institute.

An Improved Lower Bound for Approximating CVP

Irit Dinur[†‡] Guy Kindler[§¶] Shmuel Safra[‖]

Abstract

This paper shows the problem of finding the closest vector in an n-dimensional lattice to be NP-hard to approximate to within factor $n^{c/\log\log n}$ for some constant $c > 0$.

Presented at the 39th IEEE Symposium on Foundations of Computer Science, Palo Alto, California, USA, November 8-11, 1998.

[†]Tel-Aviv University, Israel
[‡]*Supported by the Deutsch Institute*
[§]Tel-Aviv University, Israel
[¶]*Supported by the Deutsch Institute*
[‖]Tel-Aviv University, Israel

PCP Characterizations of NP: Towards a Polynomially-Small Error-Probability

Irit Dinur[†‡] Eldar Fischer [§] Guy Kindler[¶‖] Ran Raz[*]* Shmuel Safra[†]†

Abstract

This paper strengthens the low-error PCP characterization of NP, coming closer to the upper limit of the BGLR conjecture. Namely, we prove that witnesses for membership in any NP language can be verified with a constant number of accesses, and with an error probability exponentially small in the number of bits accessed, where this number is as high as $\log^{\beta} n$, for *any* constant $\beta < 1$. (The BGLR conjecture claims the same for any $\beta \leq 1$).

Our results are in fact stronger, implying the Gap- Quadratic-Solvability problem to be NP-hard even if the equations are restricted to having a constant number of variables. That is, given a system of quadratic-equations over a field $\mathcal{F}$ (of size up to $2^{\log^{\beta} n}$), where each equation depends on a constant number of variables, it is NP-hard to decide between the case where there is a common solution for all of the equations, and the case where any assignment satisfies no more than a $\frac{2}{|\mathcal{F}|}$ fraction of them.

At the same time, our proof presents a *direct* construction of a low-degree-test whose error-probability is exponentially small in the number of bits accessed. Such a result was previously known only relying on recursive applications of the entire PCP theorem.

Presented at the Thirty-First Annual ACM Symposium on Theory of Computing, May 1-4, 1999.

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[‡]*Supported by the Deutsch Institute*
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Lower Bounds for On-line Scheduling with Precedence Constraints on Identical Machines

Leah Epstein[†‡]

Abstract

We consider the on-line scheduling problem of jobs with precedence constraints on m parallel identical machines. Each job has a time processing requirement, and may depend on other jobs (has to be processed after them). A job arrives only after its predecessors have been completed. The cost of an algorithm is the time that the last job is completed. We show lower bounds on the competitive ratio of on-line algorithms for this problem in several versions.

We prove a lower bound of $2 - 1/m$ on the competitive ratio of any deterministic algorithm (with or without preemption) and a lower bound of $2-2/(m+1)$ on the competitive ratio of any randomized algorithm (with or without preemption).

The lower bounds for the cases that preemption is allowed require arbitrarily long sequences. If we use only sequences of length $O(m^2)$, we can show a lower bound of $2 - 2/(m + 1)$ on the competitive ratio of deterministic algorithms with preemption, and a lower bound of $2 - O(1/m)$ on the competitive ratio of any randomized algorithm with preemption. All the lower bounds hold even for sequences of unit jobs only.

The best algorithm that is known for this problem is the well known List Scheduling algorithm of Graham. The algorithm is deterministic and does not use preemption. The competitive ratio of this algorithm is $2 - 1/m$. Our randomized lower bounds are very close to this bound (a difference of $O(1/m)$) and our deterministic lower bounds match this bound.

Presented at the 1st Workshop on Approximation Algorithms for Combinatorial Optimization Problems (APPROX98), Aalborg, Denmark, July 1998.

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On-line Machine Covering

Yossi Azar[†] Leah Epstein[‡§]

Abstract

We consider the problem of scheduling a sequence of jobs on m parallel identical machines so as to maximize the minimum load over the machines. This situation corresponds to a case that a system which consists of the m machines is alive (i.e. productive) only when all the machines are alive, and the system should be maintained alive as long as possible. It is well known that any on-line deterministic algorithm for identical machines has a competitive ratio of at least m and that greedy is an m competitive algorithm. In contrast we design an on-line randomized algorithm which is $O(\sqrt{m}\log m)$ competitive and a lower bound of $\Omega(\sqrt{m})$ for any on-line randomized algorithm. In the case where the weights of the jobs are polynomially related we design an optimal $O(\log m)$ competitive randomized algorithm and a matching tight lower bound for any on-line randomized algorithm. In fact, if F is the ratio between the weights of largest job and the smallest job then our randomized algorithm is $O(\log F)$ competitive.

A sub-problem that we solve which is interesting in its own right is the problem where the value of the optimal algorithm is known in advance. Here we show a deterministic (constant) $2 - \frac{1}{m}$ competitive algorithm. We also show that our algorithm is optimal for two, three and four machines and that no on-line deterministic algorithm can achieve a better competitive ratio than 1.75 for $m \geq 4$ machines.

Presented at the 5th Annual European Symposium on Algorithms, Graz, Austria, September 1997.

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The Design and Implementation of Planar Maps in CGAL

Eyal Flato[†] Dan Halperin Iddo Hanniel Oren Nechushtan
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Abstract

Planar maps are fundamental structures in computational geometry. They are used to represent the subdivision of the plane into regions and have numerous applications. We describe the planar map package of CGAL — the Computational Geometry Algorithms Library. We discuss problems that arose in the design and implementation of the package and report the solutions we have found for them. In particular we introduce the two main classes of the design—*planar maps* and *topological maps* that enable the convenient separation between geometry and topology. We also describe the *geometric traits* which make our package flexible by enabling to use it with any family of curves as long as the user supplies a small set of operations for the family. Finally, we present the algorithms we implemented for point location in the map, together with experimental results that compare their performance.

Presented by Eyal Flato at the 3rd International Workshop on Algorithm Engineering , London, UK, July 19-21, 1999.

[†]Department of Computer Science, Tel Aviv University, supported by the Deutsch Institute.

Multiple Structural Alignment and Core Detection by Geometric Hashing

Nathaniel Leibowitz[†] Zipora Y. Fligelman [‡] Ruth Nussinov [§¶] Haim J. Wolfson[||]

Abstract

A Multiple Structural Alignment algorithm is presented in this paper. The algorithm accepts an ensemble of protein structures and finds the largest substructure (core) of C_α atoms whose geometric configuration appear in all the molecules of the ensemble (core). Both the detection of this core and the resulting structural alignment are done simultaneously. Other large enough multi-structural superimpositions are detected as well. Our method is based on the Geometric Hashing paradigm and a superimposition clustering technique which represents superimpositions by sets of matching atoms. The algorithm proved to be efficient on real data in a series of experiments. The same method can be applied to any ensemble of molecules (not necessarily proteins) since our basic technique is sequence order independent.
Keywords : Multiple structural alignment; Geometric Hashing; invariants; structural core; transformation clustering.

Presented at the International Conference on Intelligent System for Molecular Biology, Heidleberg, Germany, August 6-10, 1999.

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TVLA: A System for Implementing Static Analyses

Tal Lev-Ami[†‡] Mooly Sagiv[§]

Abstract

We present TVLA (Three-Valued-Logic Analyzer). TVLA is a "YACC"-like framework for automatically constructing static-analysis algorithms from an operational semantics, where the operational semantics is specified using logical formulae. TVLA has been implemented in Java and was successfully used to perform shape analysis on programs manipulating linked data structures (singly and doubly linked lists), to prove safety properties of Mobile Ambients, and to verify the partial correctness of several sorting programs.

Presented at the International Static Analysis Symposium (SAS2000), Santa Barbara, USA, June 29–July 1, 2000.

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Truly Online Paging with Locality of Reference

Amos Fiat[†] Manor Mendel[‡§]

Abstract

The competitive analysis fails to model locality of reference in the online paging problem. To deal with it, Borodin *et. al.* introduced the access graph model for the paging problem, which attempts to capture the locality of reference. However, the access graph model has a number of troubling aspects. The access graph has to be known in advance to the paging algorithm and the memory required to represent the access graph itself may be very large.

In this paper we present truly online strongly competitive paging algorithms in the access graph model that do not have any prior information on the access sequence. We present both deterministic and randomized algorithms. The algorithms need only $O(k \log n)$ bits of memory, where k is the number of page slots available and n is the size of the virtual address space. *I.e.*, asymptotically no more memory than needed to store the virtual address translation table. In fact, it can be reduced to $O(k \log k)$ bits using appropriate probabilistic data structures.

Presented at the 38th Annual Symposium on Foundations of Computer Sciencee, Miami Beach, FL, U.S.A. October, 1997.

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Better Algorithms for Unfair Metrical Task Systems and Applications

Amos Fiat[†] Manor Mendel[‡§]

Abstract

Unfair metrical task systems are a generalization of online metrical task systems. In this paper we introduce new techniques to combine algorithms for unfair metrical task systems and apply these techniques to obtain the following results:

1. Better randomized algorithms for unfair metrical task systems on the uniform metric space.
2. Better randomized algorithms for metrical task systems on general metric spaces, $O(\log^2 n (\log\log n)^2)$ competitive, improving on the best previous result of $O(\log^5 n \log\log n)$.
3. A tight randomized competitive ratio for the k-weighted caching problem on $k+1$ points, $O(\log k)$, improving on the best previous result of $O(\log^2 k)$.

Presented at the thirty-second annual ACM Symposium on Theory of Computing, Portland, OR, USA, May, 2000

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An Efficient Data Structure for Feature Extraction in a Foveated Environment

Efri Nattel[†‡] Yehezkel Yeshurun[§¶]

Abstract

Foveated sampling and representation of images is a powerful tool for various vision applications. However, there are many inherent difficulties in implementing it. We present a simple and efficient mechanism to manipulate image analysis operators directly on the foveated image; A single typed table-based structure is used to represent various known operators. Using the Complex Log as our foveation method, we show how several operators such as edge detection and Hough transform could be efficiently computed almost at frame rate, and discuss the complexity of our approach.

Presented at the IEEE International Workshop on Biologically Motivated Computer Vision (BMCV2000), Seoul, Korea, May 15–17, 2000.

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Detecting Memory Errors via Static Pointer Analysis

Nurit Dor[†] Michael Rodeh[‡] Mooly Sagiv[§]

Abstract

Programs which manipulate pointers are hard to debug. Pointer analysis algorithms (originally aimed at optimizing compilers) may provide some remedy by identifying potential errors such as dereferencing `NULL` pointers by statically analyzing the behavior of programs on all their input data.

Our goal is to identify the "core program analysis techniques" that can be used when developing realistic tools which do not generate too many false alarms. It is an open question if exists a conservative technique that will yield only a modest number of false alarms, and if so, if it will scale for large programs. Our preliminary experience indicates that the following techniques are necessary: (i) finding aliases between pointers, (ii) flow sensitive techniques that account for the program control flow constructs, (iii) partial interpretation of conditional statements, (iv) analysis of the relationships between pointers, and sometimes (v) analysis of the underlying data structures manipulated by the C program.

We show that a combination of these techniques yields better results than those achieved by state of art tools.

Presented in the 1998 ACM SIGPLAN Workshop on Program Analysis for Software Tools and Engineering Montreal, CA, 14 June 1998

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On the Complexity of Positional Sequencing by Hybridization

Amir Ben-Dor[†] Itsik Pe'er[‡§] Ron Shamir[‡] Roded Sharan[‡]

Abstract

In sequencing by hybridization (SBH), one has to reconstruct a sequence from its k-long substrings. SBH was proposed as a promising alternative to gel-based DNA sequencing approaches, but in its original form the method is not competitive. Positional SBH is a recently proposed enhancement of SBH in which one has additional information about the possible positions of each substring along the target sequence. We give a linear time algorithm for solving the positional SBH problem when each substring has at most two possible positions. On the other hand, we prove that the problem is NP-complete if each substring has at most three possible positions.

Presented at the 10th Annual Symposium on Combinatorial Pattern Matching, Warwick, UK, July 22–24, 1999.

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An Algorithm Combining Discrete and Continuous Methods for Optical Mapping

Richard M. Karp[†] Itsik Pe'er[‡§] Ron Shamir[‡]

Abstract

Optical mapping is a novel technique for generating the restriction map of a DNA molecule by observing many single, partially digested copies of it, using fluorescence microscopy. The real-life problem is complicated by numerous factors: false positive and false negative cut observations, inaccurate location measurements, unknown orientations and faulty molecules. We present an algorithm for solving the real-life problem. The algorithm combines continuous optimization and combinatorial algorithms, applied to a non-uniform discretization of the data. We present encouraging results on real experimental data, and on simulated data.

Presented at the 7th international conference on Intelligent Systems for Molecular Biology, Heidelberg, Germany, August 6–10, 1999.

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Automatic Removal of Array Memory Leaks in Java

Ran Shaham[†‡] Elliot K. Kolodner[§] Mooly Sagiv[¶]

Abstract

Current garbage collection (GC) techniques do not (and in general cannot) collect all the garbage that a program produces. This may lead to a performance slowdown and to programs running out of memory space.

In this paper, we present a practical algorithm for statically detecting memory leaks occurring in arrays of objects in a garbage collected environment. No previous algorithm exists. The algorithm is conservative, i.e., it never detects a leak on a piece of memory that is subsequently used by the program, although it may fail to identify some leaks. The presence of the detected leaks is exposed to the garbage collector, thus allowing GC to collect more storage.

We have instrumented the Java virtual machine to measure the effect of memory leaks in arrays. Our initial experiments indicate that this problem occurs in many Java applications. Our measurements of heap size show improvement on some example programs.

Presented at the 9th International Conference on Compiler Construction, Berlin, Germany, March/April 2000.

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Minimizing the Flow Time without Migration

Baruch Awerbuch† Yossi Azar‡ Stefano Leonardi§ Oded Regev¶‖

Abstract

We consider the classical problem of scheduling jobs in a multiprocessor setting in order to minimize the flow time (total time in the system). The performance of the algorithm, both in offline and online settings, can be significantly improved if we allow preemption: i.e., interrupt a job and later continue its execution, perhaps migrating it to a different machine. Preemption is inherent to make a scheduling algorithm efficient. While in case of a single processor, most operating systems can easily handle preemptions, migrating a job to a different machine results in a huge overhead. Thus, it is not commonly used in most multiprocessor operating systems. The natural question is whether migration is an inherent component for an efficient scheduling algorithm, in either online or offline setting.

Leonardi and Raz (STOC'97) showed that the well known algorithm, *shortest remaining processing time* (SRPT), performs within a logarithmic factor of the optimal algorithm. Note that SRPT must use *both* preemption and migration to schedule the jobs. It is not known if better approximation factors can be reached. In fact, in the on-line setting, Leonardi and Raz showed that no algorithm can achieve a better bound.

Without migration, no (offline or online) approximations are known. This paper introduces a new algorithm that does not use migration, works *online*, and is just as effective (in terms of approximation ratio) as the best known *offline* algorithm (SRPT) that uses migration.

Presented at the Symposium on the Theory of Computing '99.

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A Polynomial Approximation Algorithm for the Minimum Fill-In Problem

Assaf Natanzon[†] Ron Shamir[†] Roded Sharan[†‡]

Abstract

In the *minimum fill-in* problem, one wishes to find a set of edges of smallest size, whose addition to a given graph will make it chordal. The problem has important applications in numerical algebra and has been studied intensively since the 1970s. We give the first polynomial approximation algorithm for the problem. Our algorithm constructs a triangulation whose size is at most eight times the optimum size squared. The algorithm builds on the recent parameterized algorithm of Kaplan, Shamir and Tarjan for the same problem.

For bounded degree graphs we give a polynomial approximation algorithm with a polylogarithmic approximation ratio. We also improve the parameterized algorithm.

Presented at the Thirtieth Annual ACM Symposium on Theory of Computing, Dallas, Texas, May 23–26, 1998.

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Complexity Classification of Some Edge Modification Problems

Assaf Natanzon[†] Ron Shamir[†] Roded Sharan[†‡]

Abstract

In an edge modification problem one has to change the edge set of a given graph as little as possible so as to satisfy a certain property. We prove in this paper the NP-hardness of a variety of edge modification problems with respect to some well-studied classes of graphs. These include perfect, chordal, chain, comparability, split and asteroidal triple free. We show that some of these problems become polynomial when the input graph has bounded degree. We also give a general constant factor approximation algorithm for deletion and editing problems on bounded degree graphs with respect to properties that can be characterized by a finite set of forbidden induced subgraphs.

Presented at the Twenty-Fifth International Workshop on Graph-Theoretic Concepts in Computer Science, Ascona, Switzerland, June 17–19, 1999.

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An Improved Bound for k-Sets in Three Dimensions

Micha Sharir† Shakhar Smorodinsky‡ Gábor Tardos§

Abstract

Let S be a set of n points in R^d. A *k-set* of S is a subset $S' \subset S$ such that $S' = S \cap H$ for some halfspace H and $|S'| = k$. The problem of determining tight asymptotic bounds on the maximum number of k-sets is one of the most intriguing open problems in combinatorial geometry. Due to its importance in analyzing geometric algorithms, the problem has caught the attention of computational geometers as well. A close to optimal solution for the problem remains elusive even in the plane. The best asymptotic upper and lower bounds in the plane are $O(nk^{1/3})$ and $n \cdot 2^{\Omega(\sqrt{\log k})}$, respectively. In this paper we obtain the following result:
Theorem: The number of k-sets in a set of n points in R^3 is $O(nk^{3/2})$.

This result improves the previous best known asymptotic upper bound of $O(nk^{5/3})$ (see Dey and Edelsbrunner and Agarwal et al.). The best known asymptotic lower bound for the number of k-sets in three dimensions is $nk \cdot 2^{\Omega(\sqrt{\log k})}$.

To be presented at the 16th Annual ACM Symposium on Computational Geometry 2000 Hong-Kong. Accepted to the special issue of the theory track.

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A Model for Visual Camouflage Breaking

Ariel Tankus[†‡] Yehezkel Yeshurun[‡]

Abstract

Some animals use counter-shading in order to prevent their detection by predators. Counter-shading means that the albedo of the animal is such that its image has a flat intensity function rather than a convex intensity function. This implies that there might exist predators who can detect 3D objects based on the convexity of the intensity function. In this paper, we suggest a mathematical model which describes a possible explanation of this detection ability. We demonstrate the effectiveness of convexity based camouflage breaking using an operator ("D_{arg}") for detection of 3D convex or concave graylevels. Its high robustness and the biological motivation make D_{arg} particularly suitable for camouflage breaking. As will be demonstrated, the operator is able to break very strong camouflage, which might delude even human viewers. Being non-edge-based, the performance of the operator is juxtaposed with that of a representative edge-based operator in the task of camouflage breaking. Better performance is achieved by D_{arg} for both animal and military camouflage breaking.

Presented at the IEEE International Workshop on Biologically Motivated Computer Vision (BMCV2000), Seoul, Korea, May 15–17, 2000.

[†]Dept. of Computer Science, Tel Aviv University, Tel Aviv, Israel
[‡]Supported by the Deutsch Institute

Detection of Regions of Interest and Camouflage Breaking by Direct Convexity Estimation

Ariel Tankus[†‡] Yehezkel Yeshurun[‡]

Abstract

Detection of Regions of Interest is usually based on edge maps. We suggest a novel non-edge-based mechanism for detection of regions of interest, which extracts 3D information from the image. Our operator detects smooth 3D convex and concave objects based on direct processing of intensity values. Invariance to a large family of functions is mathematically proved. It follows that our operator is robust to variation in illumination, orientation, and scale, in contrast with most other attentional operators. The operator is also demonstrated to efficiently detect 3D objects camouflaged in noisy areas. An extensive comparison with edge-based attentional operators is delineated.

Presented at the IEEE International Workshop on Visual Surveillance '98 (VS98), Bombay, India, January 2, 1998 (In conjunction with ICCV'98).

[†]Dept. of Computer Science, Tel Aviv University, Tel Aviv, Israel
[‡]Supported by the Deutsch Institute