شبكة المعلومات الجامعية

بسم الله الرحمن الرحيم

شبكة المعلومـــــات الجامعية

التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الالكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأفلام قد اعدت دون آية تغيرات

يجب أن

تحفظ هذه الأفلام بعيداً عن الغبار

في درجة حرارة من 15 – 20 مئوية ورطوبة نسبية من 20-40 %

To be kept away from dust in dry cool place of
15 – 25c and relative humidity 20-40 %

شبكة المعلومات الجامعية

بعض الـوثـــائق

الأصـلية تـالفـــة

بالرسالة صفحات

لم ترد بالأصـــــل

Solving the Steiner Tree Problem
for
the Design of Medical Gas System

by

Mohamed Mostafa Mohamed Ibrahim

A thesis submitted to
Faculty of Engineering at Cairo University
in Partial Fulfillment of the Requirement for
the Degree of

Master of Science

In

Systems and Biomedical Engineering

Faculty of Engineering, Cairo Unniversity
Giza, Egypt
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ABSTRACT

Modern Hospitals require large amounts of Medical Gases for assisted patient respiration as well as for the operation of medical and pneumatic equipment. These gases are delivered to the consumption sites via a Medical Gases Network; at the assigned pressures and flows. The efficiency of such networks depends mainly on the pipe routes within the departments involved. The optimal pipe route is defined as that one, which minimizes the pipe length and maintains pressure and flow limits for every gas outlet. *Finding this optimal route is the main objective of this thesis*. The routing of pipes in the Medical Gases Network is formulated as a Rectilinear Steiner Tree Problem: "given a number of gas outlets within the hospital floor, it is required to find the minimum-length interconnection between those outlets according to the rectilinear metric".

The Steiner Tree problem is first investigated. In the absence of obstacles, two classes of algorithms are incorporated: the optimal exact algorithms and the heuristic approximation algorithms. The optimal exact algorithms are discussed with emphasis on Full-set Dynamic Programming (FDP) technique as well as its improved version, which is known as the Screening Full-set Dynamic Programming (SFDP). We introduce an additional refutation procedure to SFDP where some of the candidate subsets composed of two terminals are excluded. This refutation procedure results in reducing the search space. The results of the numerical experiments showed up to 50% saving in the processing time, when compared to the original SFDP. The second class containing heuristic approximation algorithms is briefly discussed

focusing on Prim-based and Steinerization heuristics, which are expanded further to include obstacles between the terminals.

Considering any medical facility, obstacles arise as a result of the architectural constraints, which can be found in the way of medical gas pipes. Therefore, we investigate a generalization of the Steiner tree problem in the presence of obstacles. The problem in that case is referred to as an Obstacle Avoiding Rectilinear Steiner Tree. We introduce a new line-based graph, which we call Maneuver Graph. The Maneuver Graph constructs a reduced set of paths between any two terminals in the plane in the presence of obstacles. This graph is constructed in $O(m)$ operations, where m is the number of obstacles. Moreover, We developed a dynamic programming algorithm to find the shortest path between any two terminals in the plane in the presence of obstacles. This algorithm uses the Maneuver Graph after processing it to recover the shortest path with a complexity of $O(m)$. Generally, this algorithm is applied in the automation of Medical Gases pipe routing when it is required to supply a certain consumption site with a separate pipe. When many consumption sites are involved the problem is then called Single-Source Multi-Terminal Shortest Paths.

The multi-terminal interconnection is also studied using our new Obstacle Avoiding Prim-Based algorithm over the Maneuver Graph. The nearest terminal is redefined as that one with the shortest interconnection to another terminal, a Steiner or corner point of the current constructed sub-tree. This interconnection is established with minimum added tree length and maximum overlap with the already existing interconnections. For n terminals, This algorithms has a complexity of $O(n^3 m \log m)$ in the best case and $O(n^3 m^2)$ in the worst case which is still less than that of the *4 –steinerization* method. It has achieved *percentage-of-improvement* about 10% over OARMST which is better than methods of *k-steinerization*.

Finally, we discuss a Genetic Algorithm procedure adapted for the Rectilinear Steiner Tree problem. The combinatorial space of the Steiner Tree Problem, consisting of permutations of the input set of variables, made it difficult to obtain feasible solutions over the Genetic Algorithm iterations. Based on the schema proof of Goldberg concerning the convergence of the Genetic Algorithms, a set of convergence rules are extracted and applied successfully to design our Genetic Algorithm based solution. Within our treatment, the Genetic Algorithm operators have been tailored to fit the problem nature as well as using a chromosome repair procedure to