

Munkres - Topology - Chapter 3 Solutions

Section 24

Problem 24.3.

Solution: Define $g : X \rightarrow \mathbb{R}$ where $g(x) = f(x) - i_{\mathbb{R}}(x) = f(x) - x$ where $i_{\mathbb{R}}$ is the identity function. Since f and $i_{\mathbb{R}}$ are continuous, g is continuous by Theorems 18.2(e) and 21.5. Since X is connected for all three possibilities given in this problem and \mathbb{R} is ordered, the intermediate-value theorem applies.

For $X = [0, 1]$, observe that $g(0) \geq 0 - 0 = 0$ and $g(1) \leq 1 - 1 = 0$. Clearly if either $g(0)$ or $g(1)$ equals 0, then there is an $x_0 \in X$ where $f(x_0) - x_0 = 0$, so $f(x_0) = x_0$. Otherwise, $g(0) > 0$ and $g(1) < 0$, so by the intermediate-value theorem there is some $x_1 \in X$ where $g(x_1) = 0$, so $f(x_1) = x_1$.

The proposition is not necessarily true if $X = [0, 1)$ or $X = (0, 1]$. Let $f(x) = (1+x)/2$, which is obviously continuous. It follows that $f(x) = x$ if and only if $x = 1$, which not in X .

Problem 24.4.

Solution: If X has only one element, it is trivially a linear continuum, so we will assume X has at least two elements. Let $x, y \in Y$ where $x < y$. Since X is connected, $(-\infty, y)$ and (x, ∞) cannot be a separation of the space. Since the two open sets are clearly non-empty, it must be that they are not disjoint. Therefore there is some $z \in (-\infty, y) \cap (x, \infty)$, from which it follows that $z < y$ and $x < z$. We infer that $x < z < y$.

Next, let Y be a non-empty subset of X that is bounded above, and suppose Y has no supremum. Define $M = \{m \in X : m \geq y \text{ for all } y \in Y\}$ (in other words, the set of upper bounds of Y). Since Y is bounded above, M is non-empty. Then let $A = \bigcup_{y \in Y} (-\infty, y)$ and $B = \bigcup_{m \in M} (m, \infty)$. It follows that A and B are a separation of X , contradicting that X is connected. Given $x_0 \in X$, if $x_0 < y$ for some $y \in Y$, then $x_0 \in (-\infty, y) \subset A$. On the other hand, if $x_0 \geq y$ for all Y , then there is some $m \in M$ such that $m < x_0$, so $x_0 \in (m, \infty) \subset B$. Hence A and B partition X . Further, if $x_1 \in A \cap B$, then $x_1 < y$ for some $y \in Y$ and $x_1 > y'$ for all $y' \in Y$, which is impossible. Therefore A and B are disjoint. Since A and B form an impossible separation of X , we conclude that Y must have a supremum. Accordingly, X is a linear continuum.

Problem 24.4.

Solution: Given $x, y \in X \times [0, 1]$ where $x < y$, we have $x = x_0 \times x_1$ and $y = y_0 \times y_1$. Since $[0, 1]$ is a linear continuum, if $x_0 < y_0$, let $z_1 \in (x_1, 1)$; if $x_0 = y_0$, let $z_1 \in (x_1, y_1)$. Hence if $z = x_0 \times z_1$, then $x < z < y$.

Now let U be a non-empty subset of $X \times [0, 1]$ that is bounded above. Define $M = \{m \in X \times [0, 1] : m \geq a \text{ for all } a \in A\}$, which is the set of all upper bounds of A . Since A is bounded above, we're assured that M is non-empty. Designate $U = \{\pi_1(m) : m \in M\}$, which must be a non-empty subset of X . Since X is well-ordered, there is a least element x' of U . If $x' \notin \pi_1(A)$, then $x' \times 0 > a$ for all $a \in A$. Further, if $x'' < x'$, then any element of $x'' \times [0, 1]$ must be less than some element of A because no upper bound of A has a first coordinate less than x' . Hence $x' \times 0$ is the supremum of A . On the other hand, if $x' \in \pi_1(A)$, the set $V = \{\pi_2(a) : a \in A\}$ is a non-empty subset of $[0, 1]$ that is bounded above by 1, so it has a supremum y' . Accordingly, if $c \in [0, y')$, there is some $d > c$ such that $x' \times d \in A$, which is greater than $x' \times c$. Therefore $x' \times y'$ is the supremum of A , and $X \times [0, 1]$ has the supremum property. We conclude that $X \times [0, 1]$ is a linear continuum.

Problem 24.9.

Solution: Designate $X = \mathbb{R}^2 \setminus A$, and let $x, y \in X$ be given. If there is no element of A on the straight-line path in \mathbb{R}^2 from x to y , then there is obviously a path between the two points by exercise 24.8(a). In the non-trivial case where there is an element of A on the straight-line path between x and y , designate $D_0 = \{\theta \in [0, 2\pi) : \tan^{-1}[(\pi_2(a) - \pi_2(x))/(\pi_1(a) - \pi_1(x))] \neq \theta \text{ for all } a \in A\}$, which are all the angles around x for which there is no element of A on the straight line passing through x at that angle. We will show that D_0 is not empty. Assume the contrary is true and D_0 is empty. It would follow that for every element of the interval $[0, 2\pi)$, there is some element of A on the line at that angle. Consequently, there is an injection from $[0, 2\pi) \rightarrow A$. Because A is countable, there would be an injection from $[0, 2\pi) \rightarrow \mathbb{N}$, establishing that $[0, 2\pi)$ is countable, a contradiction. Therefore D_0 is not empty. Choose an arbitrary θ_0 from D_0 .

Munkres Solutions Chapter 3

Mark B. Wells



Munkres Solutions Chapter 3:

Proceedings of the Fifth Distributed Memory Computing Conference: Applications David W. Walker, Quentin F. Stout, 1990 **Parallel Computing Works!** Geoffrey C. Fox, Roy D. Williams, Guiseppe C. Messina, 2014-06-28 A clear illustration of how parallel computers can be successfully applied to large scale scientific computations This book demonstrates how a variety of applications in physics biology mathematics and other sciences were implemented on real parallel computers to produce new scientific results It investigates issues of fine grained parallelism relevant for future supercomputers with particular emphasis on hypercube architecture The authors describe how they used an experimental approach to configure different massively parallel machines design and implement basic system software and develop algorithms for frequently used mathematical computations They also devise performance models measure the performance characteristics of several computers and create a high performance computing facility based exclusively on parallel computers By addressing all issues involved in scientific problem solving Parallel Computing Works provides valuable insight into computational science for large scale parallel architectures For those in the sciences the findings reveal the usefulness of an important experimental tool Anyone in supercomputing and related computational fields will gain a new perspective on the potential contributions of parallelism Includes over 30 full color illustrations **Applied State Estimation and Association** Chaw-Bing Chang, Keh-Ping Dunn, 2016-07-08 A rigorous introduction to the theory and applications of state estimation and association an important area in aerospace electronics and defense industries Applied state estimation and association is an important area for practicing engineers in aerospace electronics and defense industries used in such tasks as signal processing tracking and navigation This book offers a rigorous introduction to both theory and application of state estimation and association It takes a unified approach to problem formulation and solution development that helps students and junior engineers build a sound theoretical foundation for their work and develop skills and tools for practical applications Chapters 1 through 6 focus on solving the problem of estimation with a single sensor observing a single object and cover such topics as parameter estimation state estimation for linear and nonlinear systems and multiple model estimation algorithms Chapters 7 through 10 expand the discussion to consider multiple sensors and multiple objects The book can be used in a first year graduate course in control or system engineering or as a reference for professionals Each chapter ends with problems that will help readers to develop derivation skills that can be applied to new problems and to build computer models that offer a useful set of tools for problem solving Readers must be familiar with state variable representation of systems and basic probability theory including random and stochastic processes Aspects of Combinatorics and Combinatorial Number Theory Sukumar Das Adhikari, 2002 *Metaheuristics for Machine Learning* Mansour Eddaly, Bassem Jarboui, Patrick Siarry, 2023-03-13 Using metaheuristics to enhance machine learning techniques has become trendy and has achieved major successes in both supervised classification and regression and unsupervised

clustering and rule mining problems Furthermore automatically generating programs via metaheuristics as a form of evolutionary computation and swarm intelligence has now gained widespread popularity This book investigates different ways of integrating metaheuristics into machine learning techniques from both theoretical and practical standpoints It explores how metaheuristics can be adapted in order to enhance machine learning tools and presents an overview of the main metaheuristic programming methods Moreover real world applications are provided for illustration e g in clustering big data machine health monitoring underwater sonar targets and banking

Discrete Mathematics Sriraman Sridharan,R. Balakrishnan,2019-07-30 Conveying ideas in a user friendly style this book has been designed for a course in Applied Algebra The book covers graph algorithms basic algebraic structures coding theory and cryptography It will be most suited for senior undergraduates and beginning graduate students in mathematics and computer science as also to individuals who want to have a knowledge of the below mentioned topics Provides a complete discussion on several graph algorithms such as Prim's algorithm and Kruskal's algorithm for finding a minimum cost spanning tree in a weighted graph Dijkstra's single source shortest path algorithm Floyd's algorithm Warshall's algorithm Kuhn Munkres Algorithm In addition to DFS and BFS search several applications of DFS and BFS are also discussed Presents a good introduction to the basic algebraic structures namely matrices groups rings fields including finite fields as also a discussion on vector spaces and linear equations and their solutions Provides an introduction to linear codes including cyclic codes Presents a description of private key cryptosystems as also a discussion on public key cryptosystems such as RSA ElGamal and Miller Rabin Finally the Agrawal Kayal Saxena algorithm AKS Algorithm for testing if a given positive integer is prime or not in polynomial time is presented the first time in a textbook Two distinguished features of the book are Illustrative examples have been presented throughout the book to make the readers appreciate the concepts described Answers to all even numbered exercises in all the chapters are given

Multivariate Data Analysis on Matrix Manifolds Nickolay Trendafilov,Michele Gallo,2021-09-15 This graduate level textbook aims to give a unified presentation and solution of several commonly used techniques for multivariate data analysis MDA Unlike similar texts it treats the MDA problems as optimization problems on matrix manifolds defined by the MDA model parameters allowing them to be solved using free optimization software Manopt The book includes numerous in text examples as well as Manopt codes and software guides which can be applied directly or used as templates for solving similar and new problems The first two chapters provide an overview and essential background for studying MDA giving basic information and notations Next it considers several sets of matrices routinely used in MDA as parameter spaces along with their basic topological properties A brief introduction to matrix Riemannian manifolds and optimization methods on them with Manopt complete the MDA prerequisite The remaining chapters study individual MDA techniques in depth The number of exercises complement the main text with additional information and occasionally involve open and or challenging research questions Suitable fields include computational statistics data analysis data mining and data science as well as theoretical

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