

ACOUSTIC SIGNAL PROCESSING IN PASSIVE SONAR SYSTEM WITH

ACOUSTIC SIGNAL PROCESSING IN PASSIVE SONAR SYSTEM WITH UNVEILING THE SILENT WORLD ACOUSTIC SIGNAL PROCESSING IN PASSIVE SONAR THE OCEAN DEPTHS A REALM OF MYSTERY AND WONDER HOLD SECRETS THAT HAVE CAPTIVATED HUMANITY FOR MILLENNIA BUT BENEATH THE WAVES LIES A WORLD SHROUDED IN DARKNESS WHERE TRADITIONAL METHODS OF EXPLORATION FAIL ENTER PASSIVE SONAR A POWERFUL TOOL THAT USES SOUND TO MAP AND UNDERSTAND THIS SILENT WORLD ITS A TECHNOLOGY THAT RELIES ON THE PRINCIPLES OF ACOUSTIC SIGNAL PROCESSING TO TRANSFORM THE FAINT WHISPERS OF THE OCEAN INTO VALUABLE INSIGHTS THE POWER OF SOUND IN THE DEEP PASSIVE SONAR OPERATES ON A SIMPLE YET ELEGANT PRINCIPLE LISTENING IT DOESNT EMIT SOUND WAVES LIKE ACTIVE SONAR SYSTEMS INSTEAD IT PATIENTLY LISTENS TO THE SOUNDS PRODUCED BY UNDERWATER OBJECTS FROM MARINE LIFE TO SHIPS AND SUBMARINES THESE SOUNDS OFTEN FAINT AND MASKED BY AMBIENT NOISE CONTAIN VALUABLE INFORMATION ABOUT THE SOURCE ITS LOCATION AND ITS CHARACTERISTICS HERES A BREAKDOWN OF THE KEY ELEMENTS IN PASSIVE SONAR HYDROPHONES THESE UNDERWATER MICROPHONES ACT AS THE EARS OF THE SONAR SYSTEM THEY CONVERT SOUND WAVES INTO ELECTRICAL SIGNALS CAPTURING THE ACOUSTIC TAPESTRY OF THE OCEAN SIGNAL PROCESSING THIS IS THE HEART OF THE SYSTEM WHERE THE MAGIC HAPPENS ADVANCED ALGORITHMS SIFT THROUGH THE RAW ACOUSTIC DATA EXTRACTING MEANINGFUL INFORMATION AND SEPARATING THE SIGNAL FROM THE NOISE ANALYSIS AND INTERPRETATION THIS FINAL STAGE TRANSLATES THE PROCESSED SIGNALS INTO ACTIONABLE INTELLIGENCE ALLOWING OPERATORS TO IDENTIFY TARGETS ASSESS THEIR MOVEMENT AND EVEN CLASSIFY THEIR TYPE ACOUSTIC SIGNAL PROCESSING THE ART OF UNMASKING THE SIGNAL THE SUCCESS OF PASSIVE SONAR HINGES ON ITS ABILITY TO EFFECTIVELY PROCESS THE CAPTURED ACOUSTIC DATA THIS INVOLVES A MULTIPRONGED APPROACH 1 NOISE REDUCTION THE OCEAN IS A NOISY PLACE THE ROAR OF WAVES THE CLICKS OF MARINE LIFE AND THE RUMBLE

OF SHIPPING TRAFFIC ALL CREATE A COMPLEX ACOUSTIC ENVIRONMENT

SIGNAL 2 PROCESSING TECHNIQUES HELP FILTER OUT THIS UNWANTED NOISE

ISOLATING THE TARGET SIGNAL

2 SIGNAL ENHANCEMENT EVEN AFTER NOISE REDUCTION THE TARGET SIGNAL MAY STILL BE WEAK AND HARD TO DISCERN TECHNIQUES LIKE MATCHED FILTERING AND BEAMFORMING HELP AMPLIFY AND CLARIFY THE SIGNAL MAKING IT EASIER TO ANALYZE

3 FEATURE EXTRACTION ONCE THE SIGNAL IS ENHANCED THE NEXT STEP IS TO EXTRACT KEY FEATURES THIS CAN INVOLVE ANALYZING THE SIGNALS FREQUENCY CONTENT ARRIVAL TIME AND TIMEFREQUENCY CHARACTERISTICS THESE FEATURES PROVIDE VALUABLE CLUES ABOUT THE SOURCE OF THE SOUND ITS LOCATION AND ITS NATURE

4 CLASSIFICATION AND IDENTIFICATION BASED ON THE EXTRACTED FEATURES ADVANCED ALGORITHMS CAN CLASSIFY THE TARGET FOR EXAMPLE A SHIPS PROPELLER NOISE WILL HAVE A DIFFERENT SIGNATURE THAN THE ECHOLOCATION CLICKS OF A DOLPHIN

5 TRACKING AND LOCALIZATION USING INFORMATION ON THE SOUNDS ARRIVAL TIME AND DIRECTION SONAR SYSTEMS CAN TRACK THE MOVEMENT OF OBJECTS AND ESTIMATE THEIR LOCATION IN REALTIME

THE APPLICATIONS OF PASSIVE SONAR PASSIVE SONAR PLAYS A CRUCIAL ROLE IN A WIDE RANGE OF APPLICATIONS INCLUDING ANTI-SUBMARINE WARFARE THIS IS PERHAPS THE MOST WELL-KNOWN APPLICATION OF PASSIVE SONAR BY LISTENING FOR THE SOUNDS OF SUBMARINES NAVAL FORCES CAN DETECT AND TRACK ENEMY VESSELS PROVIDING A CRITICAL ADVANTAGE IN UNDERWATER WARFARE

MARINE LIFE RESEARCH PASSIVE SONAR IS INCREASINGLY USED TO STUDY MARINE LIFE SCIENTISTS CAN USE IT TO MONITOR THE DISTRIBUTION AND BEHAVIOR OF WHALES DOLPHINS AND OTHER MARINE CREATURES THIS INFORMATION HELPS US UNDERSTAND THEIR HABITATS MIGRATION PATTERNS AND POTENTIAL THREATS TO THEIR SURVIVAL

OCEANOGRAPHIC RESEARCH PASSIVE SONAR CAN ALSO BE USED TO MAP THE OCEAN FLOOR IDENTIFY UNDERWATER CURRENTS AND STUDY THE INTERACTION OF SOUND WITH THE MARINE ENVIRONMENT

OIL AND GAS EXPLORATION BY LISTENING FOR THE SOUNDS OF SEISMIC ACTIVITY AND UNDERWATER GEOLOGICAL FORMATIONS PASSIVE SONAR PLAYS A ROLE IN OIL AND GAS EXPLORATION AIDING IN THE SEARCH FOR NEW RESOURCES

NAVIGATION AND SAFETY PASSIVE SONAR CAN BE USED TO HELP SHIPS AND SUBMARINES AVOID COLLISIONS WITH UNDERWATER OBSTACLES ENHANCING SAFETY IN MARITIME NAVIGATION

THE FUTURE OF PASSIVE SONAR THE FIELD OF ACOUSTIC SIGNAL PROCESSING IS CONSTANTLY EVOLVING WITH NEW TECHNIQUES AND ALGORITHMS BEING DEVELOPED TO FURTHER ENHANCE THE CAPABILITIES OF PASSIVE SONAR

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HERE ARE SOME EXCITING AREAS OF DEVELOPMENT ARTIFICIAL INTELLIGENCE AI AI ALGORITHMS ARE BEING INTEGRATED INTO PASSIVE SONAR SYSTEMS ENABLING THEM TO ANALYZE AND INTERPRET ACOUSTIC DATA WITH GREATER ACCURACY AND SPEED THAN TRADITIONAL METHODS MACHINE LEARNING MACHINE LEARNING MODELS ARE BEING TRAINED TO IDENTIFY SPECIFIC TARGETS EVEN IN THE PRESENCE OF COMPLEX NOISE AND INTERFERENCE MULTISENSOR FUSION COMBINING DATA FROM MULTIPLE HYDROPHONES AND OTHER SENSORS CAN PROVIDE A MORE COMPREHENSIVE AND ACCURATE PICTURE OF THE UNDERWATER ENVIRONMENT ADAPTIVE FILTERING ADVANCED ADAPTIVE FILTERING TECHNIQUES CAN DYNAMICALLY ADJUST TO CHANGING NOISE CONDITIONS FURTHER IMPROVING SIGNAL QUALITY PASSIVE SONAR POWERED BY CUTTINGEDGE ACOUSTIC SIGNAL PROCESSING TECHNIQUES CONTINUES TO REVOLUTIONIZE OUR UNDERSTANDING OF THE OCEAN DEPTHS ITS A TECHNOLOGY THAT ALLOWS US TO LISTEN TO THE SILENT WORLD UNLOCKING ITS MYSTERIES AND SHAPING OUR FUTURE INTERACTIONS WITH THIS VAST AND VITAL ECOSYSTEM

DIRECTION OF ARRIVAL ESTIMATION IN PASSIVE SONAR SYSTEMSRANGE, BEARING, AND POWER SPECTRUM ESTIMATION ERRORS IN PASSIVE SONARDIRECTION OF ARRIVAL ESTIMATION IN PASSIVE SONARA STUDY OF PSYCHOACOUSTICS IN PASSIVE SONAR CLASSIFICATION. PART 2. A REVIEW OF GENERAL CONCEPTS AND A DISCUSSION OF RESULTS OBTAINED TO DATE RANGE, BEARINGS, AND POWER SPECTRUM ESTIMATION ERRORS IN PASSIVE SONAR THE MILITARILY CRITICAL TECHNOLOGIES LIST THE NECESSITY FOR HIGH FREQUENCY HEARING IN PASSIVE SONAR LISTENING TARGET MOTION ANALYSIS IN PASSIVE SONAR APPLICATIONS INDEPENDENT COMPONENT ANALYSIS FOR PASSIVE SONAR SIGNAL PROCESSING ADVANCES IN SONAR TECHNOLOGY HAWAII RANGE COMPLEX SONAR SYSTEMS HANDBOOK OF ACOUSTICS QUIET SUBMARINES A SERIOUS PROBLEM SONAR SYSTEMS HEARINGS ON NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 1990 - H.R. 2461 AND OVERSIGHT OF PREVIOUSLY AUTHORIZED PROGRAMS BEFORE THE COMMITTEE ON ARMED SERVICES, HOUSE OF REPRESENTATIVES, ONE HUNDRED FIRST CONGRESS, FIRST SESSION SOVIET UNION'S UNILATERAL FORCE REDUCTION AND WITHDRAWAL PHYSICS OF PASSIVE SONAR ADVANCES IN ELECTRICAL AND COMPUTER TECHNOLOGIES PSYCHOACOUSTICS AND PASSIVE SONAR DETECTION ALI MASSOUD W. J. ALFORD ALI MASSOUD CLAUS P. JANOTA JACK WILLIAM ALFORD JOHN DONALD HARRIS J. SAN JOSÉ SPINCHEZ NATANAEL NUNES DE MOURA SERGIO SILVA NIKOLAI KOLEV MALCOLM J. CROCKER UNITED

STATES. CONGRESS. HOUSE. COMMITTEE ON ARMED SERVICES NIKOLAI KOLEV UNITED STATES. CONGRESS. HOUSE. COMMITTEE ON ARMED SERVICES. SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT UNITED STATES. CONGRESS. HOUSE. COMMITTEE ON ARMED SERVICES ROBIN HALLEY THANGAPRAKASH SENGODAN J. M. STALLARD

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LAST DECADES WITNESSED SEVERAL RESEARCH ACTIVITIES IN THE AREA OF ACOUSTIC UNDERSEA WARFARE TARGETING THE DEVELOPMENT OF ADVANCED SYSTEMS TO ACCURATELY DETECT AND LOCALIZE UNDERWATER MOVING TARGETS ONE OF THE MAIN CATEGORIES OF THESE SYSTEMS IS THE PASSIVE

SONAR SOUND NAVIGATION AND RANGING THAT SEARCHES FOR THE LOCATION OF THE SHIPS AND SUBMARINES BY LISTENING TO THE RADIATED NOISE PRODUCED BY THEIR PROPELLERS MACHINERY AND FLOW DYNAMICS THE PERFORMANCE OF THE PASSIVE SONAR INVOLVING ESTIMATION OF THE TARGET BEARING HIGHLY DEPENDS ON THE PARTICULAR ARRAY SIGNAL PROCESSING ALGORITHMS USED IN PRACTICE PRESENTLY THE MAIN CHALLENGE IS TO ACCURATELY ESTIMATE THE TARGET BEARING IN LOW SIGNAL TO NOISE RATIO FOR THE UNDERWATER ENVIRONMENT THIS BOOK PRESENTS ADVANCED HIGH SPATIAL RESOLUTION TECHNIQUES FOR BOTH UNIFORM AND NONUNIFORM HYDROPHONE ARRAYS THESE TECHNIQUES ARE NOW UTILIZED IN REAL APPLICATIONS DUE TO ITS OUTSTANDING PERFORMANCE

SINCE WORLD WAR I THE AREA OF ACOUSTIC UNDERSEA WARFARE HAS WITNESSED SEVERAL RESEARCH ACTIVITIES TARGETING THE DEVELOPMENT OF ADVANCED SYSTEMS TO ACCURATELY DETECT AND LOCALIZE UNDERWATER MOVING TARGETS ONE OF THE MAIN CATEGORIES OF THESE SYSTEMS IS THE PASSIVE SOUND NAVIGATION AND RANGING SONAR THAT SEARCHES FOR THE LOCATION OF THE SHIPS AND SUBMARINES BY LISTENING TO THE RADIATED NOISE PRODUCED BY THEIR PROPELLERS MACHINERY AND FLOW DYNAMICS THE PERFORMANCE OF THE PASSIVE SONAR HIGHLY DEPENDS ON THE PARTICULAR ARRAY SIGNAL PROCESSING ALGORITHMS USED IN PRACTICE PRESENTLY ONE OF THE MAIN CHALLENGES IS TO ACCURATELY ESTIMATE THE TARGET DIRECTION OF ARRIVAL DOA IN SEVERE UNDERWATER ENVIRONMENTS THIS THESIS IS PROPOSED TO ENHANCE THE DOA ESTIMATION IN TWO DISTINCT APPLICATIONS THIS FIRST APPLICATION IS TO IMPROVE THE SPATIAL RESOLUTION OF THE UNIFORM LINEAR TOWED ARRAYS THIS IS DONE BY APPLYING NEW SPATIAL EXTRAPOLATION TECHNIQUES CALLED 2D AND 3D FAST ORTHOGONAL SEARCH FOS FOR BOTH UNIFORM LINEAR AND RECTANGULAR ARRAYS RESPECTIVELY THE PRESENTED METHODS SHOW BETTER PERFORMANCE THAN THE CONVENTIONAL METHODS WITH RESPECT TO SIGNAL TO NOISE RATIO SNR NUMBER OF SNAPSHOTS AND ANGULAR SEPARATION MOREOVER IT REDUCES THE COMPUTATIONAL COMPLEXITY REQUIRED BY THE SPATIAL EXTRAPOLATION METHODS BASED ON LINEAR PREDICTION APPROACH THE OTHER APPLICATION CONCERNS WITH DEVELOPING A NEW DOA ESTIMATION THAT PROVIDES BETTER SPATIAL SPECTRUM THAN THE ONE PROVIDED BY CONVENTIONAL BEAMFORMING CBF WHEN A NONUNIFORM LINEAR ARRAY OF DIRECTIONAL FREQUENCY ANALYSIS AND RECORDING DIFAR SONOBUOYS IS EMPLOYED THE INTRODUCED TECHNIQUE OR THE SO CALLED

FOURTH ORDER CUMULANT BEAMFORMING FOCBF AND SHOWS AN OUTSTANDING PERFORMANCE COMPARED TO CBF ESPECIALLY IN LOW SNR FURTHERMORE A WARPING FOC BF WFOC BF METHOD OBTAINED BY AUGMENTING A WARPING BEAMFORMING TECHNIQUE WITH FOC BF IS PROPOSED TO REDUCE THE REQUIRED COMPUTATIONAL COMPLEXITY BY FOC BF WHILE PRESERVING THE SAME PERFORMANCE

THIS REPORT REVIEWS RELEVANT KNOWLEDGE IN THE CONTEXT OF PASSIVE SONAR AURAL RECOGNITION OF A NOISE SOURCE AND DEFINES AN EXPERIMENTAL APPROACH TO EXTEND THE STATE OF KNOWLEDGE IN AREAS OF IMMEDIATE CONCERN TO THE NAVAL AIR SYSTEMS COMMAND THE REPORT IS PREPARED IN TWO PARTS WITH PART 1 SUMMARIZING THE SONAR CLASSIFICATION TASK AND THEN LEADING INTO THE RELATIONSHIPS OF THIS TASK TO THE GENERAL TOPIC OF ACOUSTIC WARFARE PART 2 OF THE REPORT CONSIDERS THE AURAL CLASSIFICATION TASK IN MORE GENERAL TERMS THE RESULTS OF STUDIES USING TRAINED LISTENERS ARE PRESENTED AND ARE COMPARED TO THOSE PREDICTED FROM PREVIOUS STUDIES DONE ELSEWHERE A MODEL OF THE CLASSIFICATION TASK AS A SPECIALIZED DETECTION PROBLEM IS PRESENTED AND IT IS SHOWN THAT THE MODEL ALLOWS PREDICTION OF THE RESULTS WITHIN A FEW DB OF SIGNAL TO NOISE RATIO REQUIRED TO MAKE A TERMINAL CLASSIFICATION DECISION

AUTHOR

INDEPENDENT COMPONENT ANALYSIS FOR PASSIVE SONAR SIGNAL PROCESSING

THE DEMAND TO EXPLORE THE LARGEST AND ALSO ONE OF THE RICHEST PARTS OF OUR PLANET THE ADVANCES IN SIGNAL PROCESSING PROMOTED BY AN EXPONENTIAL GROWTH IN COMPUTATION POWER AND A THOROUGH STUDY OF SOUND PROPAGATION IN THE UNDERWATER REALM HAVE LEAD TO REMARKABLE ADVANCES IN SONAR TECHNOLOGY IN THE LAST YEARS THE WORK ON HAND IS A SUM OF KNOWLEDGE OF SEVERAL AUTHORS WHO CONTRIBUTED IN VARIOUS ASPECTS OF SONAR TECHNOLOGY THIS BOOK INTENDS TO GIVE A BROAD OVERVIEW OF THE ADVANCES IN SONAR TECHNOLOGY OF THE LAST YEARS THAT RESULTED FROM THE RESEARCH EFFORT OF THE AUTHORS IN BOTH SONAR SYSTEMS AND THEIR APPLICATIONS IT IS INTENDED FOR SCIENTIST AND ENGINEERS FROM A VARIETY OF BACKGROUNDS AND EVEN THOSE THAT NEVER HAD CONTACT WITH SONAR

TECHNOLOGY BEFORE WILL FIND AN EASY INTRODUCTION WITH THE TOPICS AND PRINCIPLES EXPOSED HERE

THE BOOK IS AN EDITED COLLECTION OF RESEARCH ARTICLES COVERING THE CURRENT STATE OF SONAR SYSTEMS THE SIGNAL PROCESSING METHODS AND THEIR APPLICATIONS PREPARED BY EXPERTS IN THE FIELD THE FIRST SECTION IS DEDICATED TO THE THEORY AND APPLICATIONS OF INNOVATIVE SYNTHETIC APERTURE INTERFEROMETRIC MULTISTATIC SONARS AND MODELING AND SIMULATION SPECIAL SECTION IN THE BOOK IS DEDICATED TO SONAR SIGNAL PROCESSING METHODS COVERING PASSIVE SONAR ARRAY BEAMFORMING DIRECTION OF ARRIVAL ESTIMATION SIGNAL DETECTION AND CLASSIFICATION USING DEMON AND LOFAR PRINCIPLES ADAPTIVE MATCHED FIELD SIGNAL PROCESSING THE IMAGE PROCESSING TECHNIQUES INCLUDE IMAGE DENOISING DETECTION AND CLASSIFICATION OF ARTIFICIAL MINE LIKE OBJECTS AND APPLICATION OF HIDDEN MARKOV MODEL AND ARTIFICIAL NEURAL NETWORKS FOR SIGNAL CLASSIFICATION THE BIOLOGY APPLICATIONS INCLUDE THE ANALYSIS OF BIOSONAR CAPABILITIES AND UNDERWATER SOUND INFLUENCE ON HUMAN HEARING THE MARINE SCIENCE APPLICATIONS INCLUDE FISH SPECIES TARGET STRENGTH MODELING IDENTIFICATION AND DISCRIMINATION FROM BOTTOM SCATTERING AND PELAGIC BIOMASS NEURAL NETWORK ESTIMATION METHODS MARINE GEOLOGY HAS PLACE IN THE BOOK WITH GEOMORPHOLOGICAL PARAMETERS ESTIMATION FROM SIDE SCAN SONAR IMAGES THE BOOK WILL BE INTERESTING NOT ONLY FOR SPECIALISTS IN THE AREA BUT ALSO FOR READERS AS A GUIDE IN SONAR SYSTEMS PRINCIPLES OF OPERATION SIGNAL PROCESSING METHODS AND MARINE APPLICATIONS

ACOUSTICAL ENGINEERS RESEARCHERS ARCHITECTS AND DESIGNERS NEED A COMPREHENSIVE SINGLE VOLUME REFERENCE THAT PROVIDES QUICK AND CONVENIENT ACCESS TO IMPORTANT INFORMATION ANSWERS AND QUESTIONS ON A BROAD SPECTRUM OF TOPICS AND HELPS SOLVE THE TOUGHEST PROBLEMS IN ACOUSTICAL DESIGN AND ENGINEERING THE HANDBOOK OF ACOUSTICS MEETS THAT NEED IT OFFERS CONCISE COVERAGE OF THE SCIENCE AND ENGINEERING OF ACOUSTICS AND VIBRATION IN MORE THAN 100 CLEARLY WRITTEN CHAPTERS EXPERTS FROM AROUND THE WORLD SHARE THEIR KNOWLEDGE AND EXPERTISE IN TOPICS RANGING FROM BASIC AERODYNAMICS AND JET NOISE TO ACOUSTICAL SIGNAL PROCESSING AND FROM THE

INTERACTION OF FLUID MOTION AND SOUND TO INFRASOUND ULTRASONICS AND QUANTUM ACOUSTICS TOPICS COVERED INCLUDE GENERAL LINEAR ACOUSTICS NONLINEAR ACOUSTICS AND CAVITATION AEROACOUSTICS AND ATMOSPHERIC SOUND MECHANICAL VIBRATIONS AND SHOCK STATISTICAL METHODS IN ACOUSTICS ARCHITECTURAL ACOUSTICS PHYSIOLOGICAL ACOUSTICS UNDERWATER SOUND ULTRASONICS QUANTUM ACOUSTICS AND PHYSICAL ASPECTS OF SOUND NOISE ITS EFFECTS AND CONTROL ACOUSTICAL SIGNAL PROCESSING PSYCHOLOGICAL ACOUSTICS SPEECH COMMUNICATION MUSIC AND MUSICAL ACOUSTICS ACOUSTICAL MEASUREMENTS AND INSTRUMENTATION TRANSDUCERS THE HANDBOOK OF ACOUSTICS BELONGS ON THE REFERENCE SHELF OF EVERY ENGINEER ARCHITECT RESEARCH SCIENTIST OR DESIGNER WITH A PROFESSIONAL INTEREST IN THE PROPAGATION CONTROL TRANSMISSION AND EFFECTS OF SOUND

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THIS MANUAL WAS DEVELOPED BY THE NAVY ELECTRONICS LABORATORY FOR USE WITH A COURSE ON SUBMARINE SONAR SUBJECTIVE ANALYSIS IT IS CONSIDERED THAT THE PRINCIPLES OF THE PHYSICS OF PASSIVE SONAR PRESENTED HEREIN APPLY TO A WIDE RANGE OF PROBLEMS IN THE SONAR CLASSIFICATION AREA AND THAT THIS PUBLICATION THEREFORE IS OF PARTICULAR IMPORTANCE TO SONARMEN AIRBORNE ASW TECHNICIANS AND OTHER ENLISTED AND OFFICER PERSONNEL CONCERNED WITH SONAR CLASSIFICATION

THIS BOOK COMPRISES A SELECTION OF PAPERS PRESENTED AT THE SIXTH INTERNATIONAL CONFERENCE ON ADVANCES IN ELECTRICAL AND COMPUTER TECHNOLOGIES ICAECT 2024 IT COMPILES GROUNDBREAKING RESEARCH AND ADVANCEMENTS IN THE FIELD OF ELECTRICAL ENGINEERING ELECTRONICS ENGINEERING COMPUTER ENGINEERING AND COMMUNICATION TECHNOLOGIES THE BOOK TOUCHES UPON A WIDE ARRAY OF TOPICS INCLUDING SMART GRIDS SOFT COMPUTING TECHNIQUES IN POWER SYSTEMS SMART ENERGY MANAGEMENT SYSTEMS AND POWER ELECTRONICS UNDER THE ELECTRICAL ENGINEERING TRACK AND BIOMEDICAL ENGINEERING ANTENNAS AND WAVEGUIDES IMAGE AND SIGNAL PROCESSING AND BROAD BAND AND MOBILE COMMUNICATION UNDER THE ELECTRONICS ENGINEERING TRACK WITH SPECIAL EMPHASIS ON COMPUTER ENGINEERING THIS BOOK HIGHLIGHTS EMERGING TRENDS IN COMPUTER VISION PATTERN RECOGNITION CLOUD COMPUTING PERVASIVE COMPUTING INTELLIGENT SYSTEMS ARTIFICIAL INTELLIGENCE NEURAL NETWORK AND FUZZY LOGIC MACHINE LEARNING DEEP LEARNING DATA SCIENCE VIDEO PROCESSING AND WIRELESS COMMUNICATION THIS IS A VALUABLE RESOURCE FOR STUDENTS RESEARCHERS AND ENGINEERS WITHIN THE FIELD OF INNOVATIVE RESEARCH AND PRACTICAL APPLICATIONS OF ELECTRICAL AND COMPUTER TECHNOLOGIES

RECOGNIZING THE QUIRK WAYS TO ACQUIRE	RIGHT SITE TO BEGIN GETTING THIS INFO.	THE LINK. YOU COULD PURCHASE LEAD
THIS BOOKS ACOUSTIC SIGNAL PROCESSING IN	ACQUIRE THE ACOUSTIC SIGNAL PROCESSING IN	ACOUSTIC SIGNAL PROCESSING IN PASSIVE
PASSIVE SONAR SYSTEM WITH IS	PASSIVE SONAR SYSTEM WITH LINK THAT WE	SONAR SYSTEM WITH OR GET IT AS SOON AS
ADDITIONALLY USEFUL. YOU HAVE REMAINED IN	MANAGE TO PAY FOR HERE AND CHECK OUT	FEASIBLE. YOU COULD QUICKLY DOWNLOAD

THIS ACOUSTIC SIGNAL PROCESSING IN PASSIVE SONAR SYSTEM WITH AFTER GETTING DEAL. SO, LIKE YOU REQUIRE THE BOOKS SWIFTLY, YOU CAN STRAIGHT GET IT. ITS SO ENORMOUSLY SIMPLE AND IN VIEW OF THAT FATS, ISNT IT? YOU HAVE TO FAVOR TO IN THIS TONE

1. WHERE CAN I BUY ACOUSTIC SIGNAL PROCESSING IN PASSIVE SONAR SYSTEM WITH BOOKS?

BOOKSTORES: PHYSICAL BOOKSTORES LIKE BARNES & NOBLE, WATERSTONES, AND INDEPENDENT LOCAL STORES. ONLINE RETAILERS: AMAZON, BOOK DEPOSITORY, AND VARIOUS ONLINE BOOKSTORES OFFER A EXTENSIVE RANGE OF BOOKS IN PHYSICAL AND DIGITAL FORMATS.

2. WHAT ARE THE VARIED BOOK FORMATS

AVAILABLE? WHICH KINDS OF BOOK FORMATS ARE PRESENTLY AVAILABLE? ARE THERE DIFFERENT BOOK FORMATS TO CHOOSE FROM? HARDCOVER: ROBUST AND LONG-LASTING, USUALLY MORE EXPENSIVE. PAPERBACK: LESS COSTLY, LIGHTER, AND MORE

PORTABLE THAN HARDCOVERS. E-BOOKS: ELECTRONIC BOOKS ACCESSIBLE FOR E-READERS LIKE KINDLE OR THROUGH PLATFORMS SUCH AS APPLE BOOKS, KINDLE, AND GOOGLE PLAY BOOKS.

3. SELECTING THE PERFECT ACOUSTIC SIGNAL

PROCESSING IN PASSIVE SONAR SYSTEM WITH BOOK: GENRES: TAKE INTO ACCOUNT THE GENRE YOU ENJOY (NOVELS, NONFICTION, MYSTERY, SCI-FI, ETC.). RECOMMENDATIONS: ASK FOR ADVICE FROM FRIENDS, PARTICIPATE IN BOOK CLUBS, OR BROWSE THROUGH ONLINE REVIEWS AND SUGGESTIONS. AUTHOR: IF YOU FAVOR A SPECIFIC AUTHOR, YOU MAY APPRECIATE MORE OF THEIR WORK.

4. TIPS FOR PRESERVING ACOUSTIC SIGNAL

PROCESSING IN PASSIVE SONAR SYSTEM WITH BOOKS: STORAGE: STORE THEM AWAY FROM DIRECT SUNLIGHT AND IN A DRY SETTING. HANDLING: PREVENT FOLDING PAGES, UTILIZE BOOKMARKS, AND HANDLE THEM WITH CLEAN HANDS. CLEANING: OCCASIONALLY DUST THE COVERS AND PAGES GENTLY.

5. CAN I BORROW BOOKS WITHOUT BUYING THEM?

PUBLIC LIBRARIES: COMMUNITY LIBRARIES OFFER A DIVERSE SELECTION OF BOOKS FOR BORROWING. BOOK SWAPS: LOCAL BOOK EXCHANGE OR INTERNET PLATFORMS WHERE PEOPLE EXCHANGE BOOKS.

6. HOW CAN I TRACK MY READING PROGRESS OR MANAGE MY BOOK CLIECTION? BOOK TRACKING

APPS: BOOK CATALOGUE ARE POPOLAR APPS FOR TRACKING YOUR READING PROGRESS AND MANAGING BOOK CLIECTIONS. SPREADSHEETS: YOU CAN CREATE YOUR OWN SPREADSHEET TO TRACK BOOKS READ, RATINGS, AND OTHER DETAILS.

7. WHAT ARE ACOUSTIC SIGNAL PROCESSING IN PASSIVE SONAR SYSTEM WITH AUDIOBOOKS, AND WHERE CAN I FIND THEM? AUDIOBOOKS: AUDIO RECORDINGS OF BOOKS, PERFECT FOR LISTENING WHILE COMMUTING OR MOLTITASKING. PLATFORMS: AUDIBLE OFFER A WIDE SELECTION OF AUDIOBOOKS.

8. HOW DO I SUPPORT AUTHORS OR THE BOOK INDUSTRY? BUY BOOKS: PURCHASE BOOKS FROM AUTHORS OR INDEPENDENT BOOKSTORES. REVIEWS:

LEAVE REVIEWS ON PLATFORMS LIKE GOODREADS.

PROMOTION: SHARE YOUR FAVORITE BOOKS ON

SOCIAL MEDIA OR RECOMMEND THEM TO FRIENDS.

9. ARE THERE BOOK CLUBS OR READING COMMUNITIES

I CAN JOIN? LOCAL CLUBS: CHECK FOR LOCAL

BOOK CLUBS IN LIBRARIES OR COMMUNITY CENTERS.

ONLINE COMMUNITIES: PLATFORMS LIKE GOODREADS

HAVE VIRTUAL BOOK CLUBS AND DISCUSSION

GROUPS.

10. CAN I READ ACOUSTIC SIGNAL PROCESSING IN

PASSIVE SONAR SYSTEM WITH BOOKS FOR FREE?

PUBLIC DOMAIN BOOKS: MANY CLASSIC BOOKS

ARE AVAILABLE FOR FREE AS THEY'RE IN THE

PUBLIC DOMAIN.

FREE E-BOOKS: SOME WEBSITES OFFER FREE E-

BOOKS LEGALLY, LIKE PROJECT GUTENBERG OR

OPEN LIBRARY. FIND ACOUSTIC SIGNAL

PROCESSING IN PASSIVE SONAR SYSTEM WITH

INTRODUCTION

THE DIGITAL AGE HAS REVOLUTIONIZED THE

WAY WE READ, MAKING BOOKS MORE

ACCESSIBLE THAN EVER. WITH THE RISE OF

EBOOKS, READERS CAN NOW CARRY ENTIRE

LIBRARIES IN THEIR POCKETS. AMONG THE

VARIOUS SOURCES FOR EBOOKS, FREE EBOOK

SITES HAVE EMERGED AS A POPULAR CHOICE.

THESE SITES OFFER A TREASURE TROVE OF

KNOWLEDGE AND ENTERTAINMENT WITHOUT THE

COST. BUT WHAT MAKES THESE SITES SO

VALUABLE, AND WHERE CAN YOU FIND THE

BEST ONES? LET'S DIVE INTO THE WORLD OF

FREE EBOOK SITES.

BENEFITS OF FREE EBOOK SITES

WHEN IT COMES TO READING, FREE EBOOK

SITES OFFER NUMEROUS ADVANTAGES.

COST SAVINGS

FIRST AND FOREMOST, THEY SAVE YOU MONEY.

BUYING BOOKS CAN BE EXPENSIVE, ESPECIALLY

IF YOU'RE AN AVID READER. FREE EBOOK SITES

ALLOW YOU TO ACCESS A VAST ARRAY OF

BOOKS WITHOUT SPENDING A DIME.

ACCESSIBILITY

THESE SITES ALSO ENHANCE ACCESSIBILITY.

WHETHER YOU'RE AT HOME, ON THE GO, OR

HALFWAY AROUND THE WORLD, YOU CAN

ACCESS YOUR FAVORITE TITLES ANYTIME,

ANYWHERE, PROVIDED YOU HAVE AN INTERNET

CONNECTION.

VARIETY OF CHOICES

MOREOVER, THE VARIETY OF CHOICES

AVAILABLE IS ASTOUNDING. FROM CLASSIC

LITERATURE TO CONTEMPORARY NOVELS, ACADEMIC TEXTS TO CHILDREN'S BOOKS, FREE EBOOK SITES COVER ALL GENRES AND INTERESTS.

TOP FREE EBOOK SITES

THERE ARE COUNTLESS FREE EBOOK SITES, BUT A FEW STAND OUT FOR THEIR QUALITY AND RANGE OF OFFERINGS.

PROJECT GUTENBERG

PROJECT GUTENBERG IS A PIONEER IN OFFERING FREE EBOOKS. WITH OVER 60,000 TITLES, THIS SITE PROVIDES A WEALTH OF CLASSIC LITERATURE IN THE PUBLIC DOMAIN.

OPEN LIBRARY

OPEN LIBRARY AIMS TO HAVE A WEBPAGE FOR

EVERY BOOK EVER PUBLISHED. IT OFFERS MILLIONS OF FREE EBOOKS, MAKING IT A FANTASTIC RESOURCE FOR READERS.

GOOGLE BOOKS

GOOGLE BOOKS ALLOWS USERS TO SEARCH AND PREVIEW MILLIONS OF BOOKS FROM LIBRARIES AND PUBLISHERS WORLDWIDE. WHILE NOT ALL BOOKS ARE AVAILABLE FOR FREE, MANY ARE.

MANYBOOKS

MANYBOOKS OFFERS A LARGE SELECTION OF FREE EBOOKS IN VARIOUS GENRES. THE SITE IS USER-FRIENDLY AND OFFERS BOOKS IN MULTIPLE FORMATS.

BookBoon

BOOKBOON SPECIALIZES IN FREE TEXTBOOKS AND BUSINESS BOOKS, MAKING IT AN EXCELLENT RESOURCE FOR STUDENTS AND PROFESSIONALS.

HOW TO DOWNLOAD EBOOKS SAFELY

DOWNLOADING EBOOKS SAFELY IS CRUCIAL TO AVOID PIRATED CONTENT AND PROTECT YOUR DEVICES.

AVOIDING PIRATED CONTENT

STICK TO REPUTABLE SITES TO ENSURE YOU'RE NOT DOWNLOADING PIRATED CONTENT. PIRATED EBOOKS NOT ONLY HARM AUTHORS AND PUBLISHERS BUT CAN ALSO POSE SECURITY RISKS.

ENSURING DEVICE SAFETY

ALWAYS USE ANTIVIRUS SOFTWARE AND KEEP YOUR DEVICES UPDATED TO PROTECT AGAINST MALWARE THAT CAN BE HIDDEN IN DOWNLOADED FILES.

LEGAL CONSIDERATIONS

BE AWARE OF THE LEGAL CONSIDERATIONS WHEN DOWNLOADING EBOOKS. ENSURE THE SITE HAS THE RIGHT TO DISTRIBUTE THE BOOK AND THAT YOU'RE NOT VIOLATING COPYRIGHT LAWS.

USING FREE EBOOK SITES FOR EDUCATION

FREE EBOOK SITES ARE INVALUABLE FOR EDUCATIONAL PURPOSES.

ACADEMIC RESOURCES

SITES LIKE PROJECT GUTENBERG AND OPEN LIBRARY OFFER NUMEROUS ACADEMIC RESOURCES, INCLUDING TEXTBOOKS AND SCHOLARLY ARTICLES.

LEARNING NEW SKILLS

YOU CAN ALSO FIND BOOKS ON VARIOUS SKILLS, FROM COOKING TO PROGRAMMING, MAKING THESE SITES GREAT FOR PERSONAL DEVELOPMENT.

SUPPORTING HOMESCHOOLING

FOR HOMESCHOOLING PARENTS, FREE EBOOK SITES PROVIDE A WEALTH OF EDUCATIONAL MATERIALS FOR DIFFERENT GRADE LEVELS AND SUBJECTS.

GENRES AVAILABLE ON FREE EBOOK SITES

THE DIVERSITY OF GENRES AVAILABLE ON FREE EBOOK SITES ENSURES THERE'S SOMETHING FOR EVERYONE.

FICTION

FROM TIMELESS CLASSICS TO CONTEMPORARY BESTSELLERS, THE FICTION SECTION IS BRIMMING WITH OPTIONS.

NON-FICTION

NON-FICTION ENTHUSIASTS CAN FIND BIOGRAPHIES, SELF-HELP BOOKS, HISTORICAL TEXTS, AND MORE.

TEXTBOOKS

STUDENTS CAN ACCESS TEXTBOOKS ON A WIDE RANGE OF SUBJECTS, HELPING REDUCE THE FINANCIAL BURDEN OF EDUCATION.

CHILDREN'S BOOKS

PARENTS AND TEACHERS CAN FIND A PLETHORA OF CHILDREN'S BOOKS, FROM PICTURE BOOKS TO YOUNG ADULT NOVELS.

ACCESSIBILITY FEATURES OF EBOOK SITES

EBOOK SITES OFTEN COME WITH FEATURES THAT ENHANCE ACCESSIBILITY.

AUDIOBOOK OPTIONS

MANY SITES OFFER AUDIOBOOKS, WHICH ARE GREAT FOR THOSE WHO PREFER LISTENING TO

READING.

ADJUSTABLE FONT SIZES

YOU CAN ADJUST THE FONT SIZE TO SUIT YOUR READING COMFORT, MAKING IT EASIER FOR THOSE WITH VISUAL IMPAIRMENTS.

TEXT-TO-SPEECH CAPABILITIES

TEXT-TO-SPEECH FEATURES CAN CONVERT WRITTEN TEXT INTO AUDIO, PROVIDING AN ALTERNATIVE WAY TO ENJOY BOOKS.

TIPS FOR MAXIMIZING YOUR EBOOK EXPERIENCE

TO MAKE THE MOST OUT OF YOUR EBOOK READING EXPERIENCE, CONSIDER THESE TIPS.

CHOOSING THE RIGHT DEVICE

WHETHER IT'S A TABLET, AN E-READER, OR A SMARTPHONE, CHOOSE A DEVICE THAT OFFERS A COMFORTABLE READING EXPERIENCE FOR YOU.

ORGANIZING YOUR EBOOK LIBRARY

USE TOOLS AND APPS TO ORGANIZE YOUR EBOOK COLLECTION, MAKING IT EASY TO FIND AND ACCESS YOUR FAVORITE TITLES.

SYNCING ACROSS DEVICES

MANY EBOOK PLATFORMS ALLOW YOU TO SYNC YOUR LIBRARY ACROSS MULTIPLE DEVICES, SO YOU CAN PICK UP RIGHT WHERE YOU LEFT OFF, NO MATTER WHICH DEVICE YOU'RE USING.

CHALLENGES AND LIMITATIONS

DESPITE THE BENEFITS, FREE EBOOK SITES COME WITH CHALLENGES AND LIMITATIONS.

QUALITY AND AVAILABILITY OF TITLES

NOT ALL BOOKS ARE AVAILABLE FOR FREE, AND SOMETIMES THE QUALITY OF THE DIGITAL COPY CAN BE POOR.

DIGITAL RIGHTS MANAGEMENT (DRM)

DRM CAN RESTRICT HOW YOU USE THE EBOOKS YOU DOWNLOAD, LIMITING SHARING AND TRANSFERRING BETWEEN DEVICES.

INTERNET DEPENDENCY

ACCESSING AND DOWNLOADING EBOOKS REQUIRES AN INTERNET CONNECTION, WHICH CAN BE A LIMITATION IN AREAS WITH POOR

CONNECTIVITY.

FUTURE OF FREE EBOOK SITES

THE FUTURE LOOKS PROMISING FOR FREE EBOOK SITES AS TECHNOLOGY CONTINUES TO ADVANCE.

TECHNOLOGICAL ADVANCES

IMPROVEMENTS IN TECHNOLOGY WILL LIKELY MAKE ACCESSING AND READING EBOOKS EVEN MORE SEAMLESS AND ENJOYABLE.

EXPANDING ACCESS

EFFORTS TO EXPAND INTERNET ACCESS GLOBALLY WILL HELP MORE PEOPLE BENEFIT FROM FREE EBOOK SITES.

ROLE IN EDUCATION

AS EDUCATIONAL RESOURCES BECOME MORE DIGITIZED, FREE EBOOK SITES WILL PLAY AN INCREASINGLY VITAL ROLE IN LEARNING.

CONCLUSION

IN SUMMARY, FREE EBOOK SITES OFFER AN INCREDIBLE OPPORTUNITY TO ACCESS A WIDE RANGE OF BOOKS WITHOUT THE FINANCIAL BURDEN. THEY ARE INVALUABLE RESOURCES FOR READERS OF ALL AGES AND INTERESTS, PROVIDING EDUCATIONAL MATERIALS, ENTERTAINMENT, AND ACCESSIBILITY FEATURES. SO WHY NOT EXPLORE THESE SITES AND DISCOVER THE WEALTH OF KNOWLEDGE THEY OFFER?

FAQs

ARE FREE EBOOK SITES LEGAL? YES, MOST FREE EBOOK SITES ARE LEGAL. THEY TYPICALLY OFFER BOOKS THAT ARE IN THE PUBLIC DOMAIN OR HAVE THE RIGHTS TO DISTRIBUTE THEM.

HOW DO I KNOW IF AN EBOOK SITE IS SAFE? STICK TO WELL-KNOWN AND REPUTABLE SITES

LIKE PROJECT GUTENBERG, OPEN LIBRARY, AND GOOGLE BOOKS. CHECK REVIEWS AND ENSURE THE SITE HAS PROPER SECURITY MEASURES.

CAN I DOWNLOAD EBOOKS TO ANY DEVICE?

MOST FREE EBOOK SITES OFFER DOWNLOADS IN MULTIPLE FORMATS, MAKING THEM COMPATIBLE WITH VARIOUS DEVICES LIKE E-READERS, TABLETS, AND SMARTPHONES. DO FREE EBOOK

SITES OFFER AUDIOBOOKS? MANY FREE EBOOK SITES OFFER AUDIOBOOKS, WHICH ARE PERFECT FOR THOSE WHO PREFER LISTENING TO THEIR BOOKS. HOW CAN I SUPPORT AUTHORS IF I USE FREE EBOOK SITES? YOU CAN SUPPORT AUTHORS BY PURCHASING THEIR BOOKS WHEN POSSIBLE, LEAVING REVIEWS, AND SHARING THEIR WORK WITH OTHERS.

