



Sveučilište u Zagrebu

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**STEGANOGRAFSKI MODEL BLISKOGA
INFRACRVENOGA SIGURNOSNOGA
TISKA POMORSKIH KARATA**

DOKTORSKI RAD

Mentor:
Damir Modrić

Zagreb, 2020. godine



University of Zagreb

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**STEGANOGRAPHIC MODEL OF
NEAR-INFRARED SECURITY PRINTING
OF NAUTICAL CHARTS**

DOCTORAL DISSERTATION

Supervisor:
Damir Modrić

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Povjerenstvo za obranu doktorskoga rada donijelo je sljedeću odluku:

„Obranio s ocjenom summa cum laude (*s najvećom pohvalom*) jednoglasnom odlukom Povjerenstva“

Sažetak

U cilju zaštite autorskih prava hidrografskih organizacija koje izdaju pomorske karte, te posebno radi očuvanja razine sigurnosti plovidbe, nužno je smanjiti rizik od krivotvorenja. Stoga se predlaže i opravdava uvođenje sigurnosnih elemenata zaštite pomorskih karata. Uz ranije poznate i praktično primjenjive elemente zaštite (vodeni žig u papiru i hologram), uvode se novi sigurnosni elementi temeljeni na InfrareDesign® (IRD) tiskarskoj tehnologiji.

Cilj istraživanja je prijedlog nove sistematizacije i uvođenje novog učinkovitog modela zaštite službenih pomorskih karata od krivotvorenja. Na taj se način utječe na pouzdanost informacijskog sadržaja i posljedično na podizanje razine sigurnosti plovidbe.

Zaštita pomorskih karata od krivotvorenja ima dvostruku ulogu. Prva je zaštita autorskih prava izdavača, kojima se krivotvorenjem nanosi određena financijska šteta. Druga uloga predloženog modela zaštite je u očuvanju razine sigurnosti plovidbe. Naime, korištenje pomorskih karata koje nisu izdane i ažurirane od strane ovlaštenog ureda i organiziranog sustava distribucije, mogu dovesti u opasnost korisnika odnosno plovilo, teret i posadu.

U tehnološkom smislu, primjena novog sustava boja ne postavlja nikakve posebne zahtjeve, obzirom da se za pomorske karte primjenjuju klasična i digitalna tehnologija. Obe navedene tehnologije bazirane su na tisku odnosno ispisu procesnim CMYK bojama. Prednost takve definicije boja je upravo mogućnost primjene različitih tiskarskih tehnologija.

Informacijska perspektiva uvođenja novog sustava boja je omogućavanje potpune kontrole nad informacijskim sadržajem pomorske karte. Informacijski sadržaj karte je podijeljen po kriterijima nautičke važnosti.

Kako bi se provjerila učinkovitost novih zaštitnih elemenata u temu je uključena i grafička forenzika koje se bavi sprječavanjem krivotvorenja i vještačenjem spornih dokumenata.

Uvođenje novog sustava boja i primjena IRD tehnologije skrivene slike na pomorskim kartama je korak prema svojevrsnoj "proširenoj stvarnosti". Informacijski sadržaj koji nije dostupan ljudskom oku na ovaj način postaje stvaran pomoću uređaja za detekciju i promatranje u NIR području. "Proširena stvarnost" potpuno novi način interpretacije informacija, do sada neprimjenjen u praksi hidrografskih ureda u svijetu, na način da se uvodi dualna slika odnosno dualni informacijski sadržaj.

Ključne riječi: pomorska karta, zaštita od krivotvorenja, steganografski model, sigurnosni tisak, InfrareDesign tehnologija

Extended abstract

Official nautical charts (eng. chart, sea chart, marine chart; fra. carte marine; ger. Seekarte; ita. carta nautica, carta marina, cro. pomorska karta) are one of the basic navigation aids.

Given their purpose and method of publishing, they are copyrighted documents. Their counterfeiting, in addition to some financial harm to the publisher, could put the user at risk at sea. Forged nautical charts can cause an imminent threat to navigation safety and endanger human lives at sea. In order to ensure the reliability of the information content of nautical charts and to preserve the level of navigation safety, it is necessary to minimize the risk of counterfeiting.

Therefore, it is proposed and justified to introduce security features for the protection of nautical charts. In addition to the previously known and practically applicable security features (watermarked paper and hologram), new security features based on InfrareDesign® (IRD) hidden image technology, are being introduced.

The steganographic model of near-infrared (NIR) security printing using IRD technology enables the protection of nautical charts to be raised to a higher level using existing conventional and digital printing techniques. Besides counterfeit prevention, the application of this model also enables the expansion of information content without affecting the visual clarity of the map in the visible spectrum.

There are international recommendations on the use of colours regarding nautical charts but there is no information on the spectrographic composition of these colours. Therefore, spectrographic measurement of colours is carried out, which extends beyond the visible to the near-infrared part of the spectrum. Spectroscopy is the starting point for the unambiguous and scientifically based proposal for the application of new colours on nautical charts.

In order to test the effectiveness of new security features, besides graphic technology, this multidisciplinary topic also includes the field of graphic forensics, which deals with, among other things, the prevention of counterfeiting and the examination of questioned documents.

Protection of official nautical charts against counterfeiting

In order to protect the copyright of hydrographic organizations that issue nautical charts, and in particular to preserve the level of navigation safety, it is necessary to reduce the risk of

counterfeiting. To protect official nautical charts against counterfeiting, security elements in material, printing/press and colours may be applied.

In this regard, it is proposed to introduce security elements at three levels:

- 1. Watermark in cartographic paper,*
- 2. Publisher Trademark Hologram and*
- 3. Application of Infraredesign hidden image technology.*

Infraredesign® (IRD) technology is suitable for the nautical charts because it can be applied to the various classical and digital printing technologies that are used to produce them.

The use of Infraredesign technology enables the selection of information content that will be visible or invisible in a particular part of the electromagnetic spectrum.

For example, a hydrographic original (with all depth marks) can be used for special purposes, as hidden or invisible information in the visible part of the spectrum, which at the same time will be visible in the near-infrared part of the spectrum.

The main activity of hydrography involves the preparation and creation of hydrographic data in order to produce hydrographic originals. The hydrographic original is the basis according to which nautical charts, plans and other publications relevant to navigation safety, are made.

To maintain the visibility of the chart, the information contained in the hydrographic original shall be reduced by map generalization only to display the depths necessary for safe navigation. Most of the depth information obtained from the hydrographic survey is reduced and does not appear on the chart.

Through the use of the IRD technology, the visual status of the chart in the visible part of the spectrum (in daylight or artificial light), remains unchanged. Hidden additional information from the hydrographic original is visible when verifying the issue's authenticity, as well as for observation for special purposes.

The infrared property of the dye disables recording, scanning or any other unauthorized copying or reproduction.

Besides the protection against counterfeiting, it is possible to expand the information content of the nautical chart for the purpose of raising the level of navigation safety. Furthermore, additional informational content can be used for special purposes, for example, military and

similar purposes, maritime-technical or commercial purposes (fishing, underwater construction, construction of marinas and harbours, etc.).

This dissertation will show new methods of creating security graphics by programmed colour mixing intended for two separate wavelength ranges.

The purpose of the research

The purpose of the research is to offer a systematization and introduction of a new effective model to protect official nautical charts against counterfeiting. This will affect the reliability of the information content and consequently increase the level of navigation safety.

The specific objective is to introduce new spectrographic characteristics of colours that are applicable to different nautical chart printing techniques.

A new information system for the absorption characteristics of colours in the visible and near infrared region will be introduced, thereby extending the information content on nautical charts.

Research Hypotheses

- 1. Based on InfrareDesign® printing technology, a new steganographic model of infrared security printing of nautical charts will be developed.*
- 2. The application of the new model will allow the information content of the charts to expand, which will be visible only in the near infrared region.*
- 3. Key parameter identification of twin colours is based on spectrographic colour tests.*
- 4. A completely new model to protect nautical charts from counterfeiting will be proposed to the International Hydrographic Organization.*

Expected scientific contribution of the proposed research

The expected scientific contribution is the development of a new steganographic model for the protection of nautical charts against counterfeiting. A new systematization will be introduced while applying safety elements in the printing of nautical charts in material, printing and colourants.

Furthermore, contribution is in expansion of the information content of nautical charts with the hidden level of information in the infrared part of the spectrum. The optimal values of CMYKIR separation will be determined in the range of standard process dyes in nautical chart printing by different printing technologies.

Protection model proposal

In addition to analysis and proposal of previously known and applicable methods of protection, such as watermarks and holograms, the focus of the dissertation is on the introduction and application of IRD technology. Aside from counterfeiting protection, as its basic role, with the application of IRD technology, it is possible to expand the information content of the nautical chart or to display additional information important for navigation safety.

Research into the application of IRD technology has contributed to the functionality and protection of products and copyrights and thereby introduced a new field of operation and development of dye management technologies as well as detection systems. In doing so, they have become crucial when it comes to security.

In terms of communication and information, the steganographic model of applying a hidden image, is a significant breakthrough.

InfraredDesign® printing technology is the result of a long research by Croatian scientists in the field of colours and dyes in the visible - V (visible) and invisible near infrared - NIR (near infrared) parts of the spectrum. Its application has been tested and developed for various types of dyes and printing techniques, from offset press, flexo and screen printing, to digital printing technologies.

It is a steganographic method of hiding and transmitting information in order to conceal secret messages so that they are completely invisible to a third party during the transfer to the recipient and during the application.

Document verification is possible due to the specific dye response in the visible and near-infrared spectrum. CMYKIR separation (Cyan, Magenta, Yellow, K-Black, InfraRed) is introduced in printing technology with a unique system of colour management that connects visible and near-infrared range of electromagnetic radiation.

The visibility of graphical elements with the help of instruments in the wavelength from 700 to 1000 nm allows programming of the choice of information visibility with common process colours. So there is no introduction of additional colours or special printing techniques.

The development of graphic technology and the application of scientific advances in the field of printing have enabled the application of new security printing methods. However, the availability of digital copiers, scanners and image processing software, as well as digital printing devices, has at the same time, greatly simplified the possibility of counterfeiting.

That is why the challenge of applying security features in printing with new technologies lies in designing elements that cannot be copied or scanned. While establishing security for official documents, security features are systematized with clearly indicated graphic materials and printing technologies.

Authorized safety features such as hologram and watermark, infrared - IR or ultraviolet - UV printing are used for large editions. Near-infrared electromagnetic radiation is observed from 700 nm to 1000 nm, while ultraviolet radiation is in the wavelength range from 10 to 400 nm.

In the case of authorized protection of official documents, the principle is to apply at least one visible element of protection together with one hidden colour protection or hidden information in eg. IR or UV spectrum.

Keywords: *nautical chart, counterfeiting protection, steganographic model, security printing, InfraredDesign technology*