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Improving the Quality of Student Cards Using AI

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Abstract

Using the advantages of being a relatively small county and the existence of a central e-infrastructure institution for academia and research, Croatia fosters multiple national information systems in the higher education (HE) area. This has created the sound ecosystem that has enabled the creation of first nation-wide European Student Card (ESC), among others. Student cards are frequently used daily, mainly because of the student nourishment system which is in place in Croatia but also for other purposes. The new student card is also available in the digital format, in a national digital wallet mobile application. However, one of the main identifying principles remains the same – the visual inspection of the student's photograph. Therefore, it is important to ensure the quality of the future card photograph which is being submitted by the student. In this article, we present the leverage of AI method to improve the quality of those photographs. The method is based on multiple convolutional neural networks (CNNs).

1 Introduction

1.1 The basis of the national HE infrastructure ecosystem

The University Computing Centre of University of Zagreb (SRCE) was established in 1971, when University of Zagreb was the sole university of Croatia. Immediately it took upon significant projects towards establishing various infrastructures in academia and research (A&R) – from network layer, through computing to applications and education. As the Croatian HE landscape expanded and new HEI were introduced, SRCE provided its services to all of them.

With the development of technology and the awareness of the digitalization potential, different initiatives arose. SRCE recognized the values of common e-infrastructures and lead or took part in multiple projects aimed to build them. The financial, but more importantly, legislative support of Croatian Ministry of Science and Education (MSE) was crucial over time. Being a relatively small country and having most of the HE financed by the state, MSE too recognized the value of common infrastructures which should be freely available to all stakeholders of HE. Today, SRCE is the central A&R e-infrastructure institution, building and maintaining nation-wide A&R services related to network, data centres, high-performance computing, education, and of course, data and information systems.

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In the rest of this section, the most important systems related to student identity in Croatia are introduced, namely the Student Rights Information System (ISSP) and Academic ID-cards Management System (ISAK). Also, other crucial systems in the informational HE landscape are also briefly explained. SRCE provides numerous benefits to HEIs and other stakeholders of these systems, including complimentary user training, technical support, and ongoing maintenance. Needless to say, these systems are mostly interconnected to one another, thus not only exchanging information, but also complementing the mutual processes.

1.2 ISSP and ISAK

The **Student Rights Information System** (ISSP), established 25 years ago, initially focused on facilitating and overseeing the financial aspects related to student restaurants and nourishment. Its primary objective was to implement and monitor the funding allocated for student meals, based on predefined rules and the meticulous tracking, and reporting of the meals sold.

Over time, ISSP has evolved into a comprehensive system maintaining and executing daily computation of student benefit levels. This system houses extensive data about all students in Croatia and serves as a paramount data source for students and diverse reports. Leveraging REST API technology for integration, ISSP is also a critical data source for numerous external systems [9]. This system is a caretaker of the Croatian national unique student identifier (JMBAG) which consists of 11 digits. Having a unique nation-wide student identifier makes the process of creating European Student Identifier (ESI) for Croatia easy. Croatian students' ESI is "HR:" concatenated to JMBAG.

Complementary to ISSP and intricately linked with it, the **Academic ID-cards Management System** (ISAK) serves as a vital component for issuing and managing student cards. ISAK revolves around the central function of facilitating the issuance and administration of student cards, contributing to a cohesive and efficient information ecosystem within the educational landscape.

1.3 ISVU, ISeVO, AAI and Merlin

The **Higher Education Information System** (ISVU) [8] is a business-oriented system for HEIs and the most complex one. It is a national student management system (SMS), first put in production in 2001. Now, it is used by all public HEIs (over 110), designed to support the operational processes associated with teaching and the monitoring of students' academic journeys. Aligned with legal acts, statutes, and regulations ISVU facilitates the management of extensive databases encompassing students, professors, courses, curricula, enrolments, mobility, exams, etc.

The primary goal of constructing the **Higher Education Registers System** (ISeVO) [12] is to establish a unified platform that houses accurate, comprehensive, and reliable information, serving as the cornerstone for decision-making across all levels of the higher education system. ISeVO is being built during an on-going project until the start of 2026.

While ISVU is helping day-to-day operation of HEIs, ISeVO is envisioned to facilitate tracking, reporting, analysis, and proactive planning within HE, fostering systematic monitoring, evaluation, and goal recognition in program financing. Through systematic monitoring and regular evaluation, the efficiency of HEIs and the effective use of public funds are expected to improve, providing the necessary conditions for delivering more relevant and higher-quality education. ISeVO is anticipated to play a crucial role in strategic planning, evidence-based policy governance, operational management, and presenting the potential of the country and HEIs in both written and digital formats.

AAI@EduHr [16] is an authentication and authorization infrastructure of research and higher education in the Republic of Croatia, in production since 2006. AAI@EduHr is based on the use of distributed LDAP Directories. Each institution within the research and higher education community has its own LDAP Directory where all electronic identities of users from that institution have been stored. Every student in Croatia has an AAI@EduHr electronic identity, which can be used to take part in over 900 different services. This system has been connected to global services eduroam [7] and eduGAIN [5], and to the Croatian eIDAS node (NIAS).

Since AAI@EduHr is a Croatian electronic identity standard, it is JMBAG-aware (a national student unique identifier). Therefore, as a part of the authentication response, it is able to provide an ESI to the service to which a student is authenticating.

Merlin [11] is Moodle [13] based system, additionally enriched with different functionalities of specific value to Croatian HE. It is a *de facto* standard Learning Management System (LMS) in Croatia, with over 90 HEIs and more than 30.000 e-learning courses yearly. Merlin is connected to ISVU and Dabar [2], a platform of institutional repositories, also developed and maintained by SRCE.

It is worth noting that both ISVU and Merlin (SMS and LMS) use ESI identifier and are eduGAIN-enabled. That means that guest students on a mobility can continue using their own electronic identity while in Croatia.

2 Student Card

In Croatia, the student card assumes paramount significance as a ubiquitous and essential student service. Functioning as a multifaceted medium, it serves the pivotal role of authenticating students within HEIs and facilitates access to an array of ancillary services, including but not limited to student restaurants, cafeterias, bookstores, and other on-campus facilities. Notably, Croatia stands as the inaugural member of the European Union (EU) to be the first to implement a novel student card requirements on national level. This card, designed to adhere to the regulations of the European Student Card Initiative [4], inherently acquires the status of a ESC, as seen in Figure 1a. Beyond the immediate advantages of being valid throughout the entire duration of both undergraduate and graduate studies, thereby proving advantageous over the long term, the technological enhancement of student cards introduces heightened security measures for the safeguarding of personal data. Additionally, the student card is available in a digital format (digital wallet mobile application) within AKD Certilia [1], enabling students to authenticate themselves and audit diverse student services with utmost convenience, as shown in Figure 1b.

A key features of the student card, made on plastic medium, are shown in the Figure 1a:

1. Chip Mifare DESFire EV3 - is the latest standard in developing contactless smart cards, developed by NXP Semiconductors. The advanced security features ensure high level of data protection between the card and the reader, and the new memory structure allows the storage of multiple applications on the card, which is especially important for service providers and their custom applications which target student population.
2. ESC Hologram - certifies the card's authenticity at European level.
3. ESC QR Code - certifies the card's validity at European level.
4. ESI - is a digital identifier that facilitates the unique identification of students during their online interactions with student mobility services. The ESI plays a crucial role

(a) (b)

Figure 1: Student card in Croatia: (a) on plastic medium, and (b) in a digital wallet mobile application - Certilia. Both images show the key features.

in supporting and streamlining international student mobility, fostering transnational collaboration among HEIs.

5. Tactile Braille embossing - ensures accessibility and inclusivity for individuals with visual impairments by incorporating rasied dots that contain information.

6. Country Code - which uniquely identifies the origin country of the card holder's HEI.

The digital format of a student card shares its design elements with its physical counterpart, including basic student data. However, it incorporates distinctive key features, as shown in Figure 1b:

1. Notification area - system-generated messages sent to inform student about changes in card status and any modifications to subscribed student services.

2. QR Code - certifies the card's validity at national level.

3. Student services - status and associated data of subscribed student services.

4. Student HEI data - basic information about the enrolled HEI.

In addition to the enumerated features, both physical and digital card encompass essential identifying elements, namely the appellation of the HEI, as well as the given name, surname, and a corresponding personal photograph of the cardholder. A clearly visible personal photograph is of utmost importance, as it serves as the primary subject in visually identifying the cardholder. Recognizing the significance of this aspect, we propose a novel proof-of-concept method founded on machine learning techniques to enhance the clarity and quality of images for student cards, thereby contributing to more effective visual identification processes.

3 The Student Photo Quality Enhancement method

A novel proof-of-concept methodology for the enhancement of student card photographs is presented in Figure 2. This method comprises four modules designed to validate and transform the input image of a student into an image meeting specified criteria for a clearly visible student face. The modules include the validation module, preprocessing module, detection module, and postprocessing module.

The validation module, serving as the initial module, takes a student image imported into the SMS as an input parameter. This module consists of three distinct steps, each assessing various attributes of the image. In the first step, the file type undergoes validation, with the system expecting the input to be one of the supported image types (e.g., JPG, JPEG, or PNG) and ensuring that the image size does not exceed a predefined value. The second step involves the validation of image resolution, requiring a minimal resolution of 800×600 pixels for subsequent processing steps, guaranteeing the production of a high-quality printed image. In the final step, the system validates Exchangeable image file format (EXIF) data. EXIF data is a standard that specifies the formats for images, sound, and ancillary tags used by digital cameras (including smartphones) and other systems handling image and sound files [6]. In the context of the proposed method, the EXIF data timestamp and orientation serves as a valuable source of information embedded within the digital image file. The image's age should not surpass the predefined value set by the HEI, and it should exhibit portrait orientation (orientation key equal to one). While the availability of EXIF data may vary, the check can be optionally skipped, and the required information can be manually validated by the HEI.

The second module of the proposed method is dedicated to image preprocessing, a critical phase in enhancing the quality and uniformity of the input images. Image preprocessing encompasses fundamental techniques such as image resolution normalization and image color space normalization, both of which play pivotal roles in optimizing subsequent processing steps. Image resolution normalization is particularly relevant in the context of machine learning and CNNs, which often demand extensive computational resources for effective performance in computer vision tasks. Given the diverse sources of student images, especially in HEIs where students capture their own student card photographs, variations in resolutions are common. To mitigate the computational load and processing time, the input image undergoes scaling down to dimensions of 800×600 pixels while preserving the aspect ratio. This normalization not only aligns with the expectations of CNN models but also enhances computational efficiency. Moreover, the CNN model requires input images in a fixed color mode, necessitating image color space normalization. In this step, all images are uniformly converted to the RGB color space, ensuring consistency in the representation of color information. Upon the successful completion of the aforementioned preprocessing steps, the image is forwarded to the detection module.

The third module, detection module, contains the most crucial steps in student card photo-

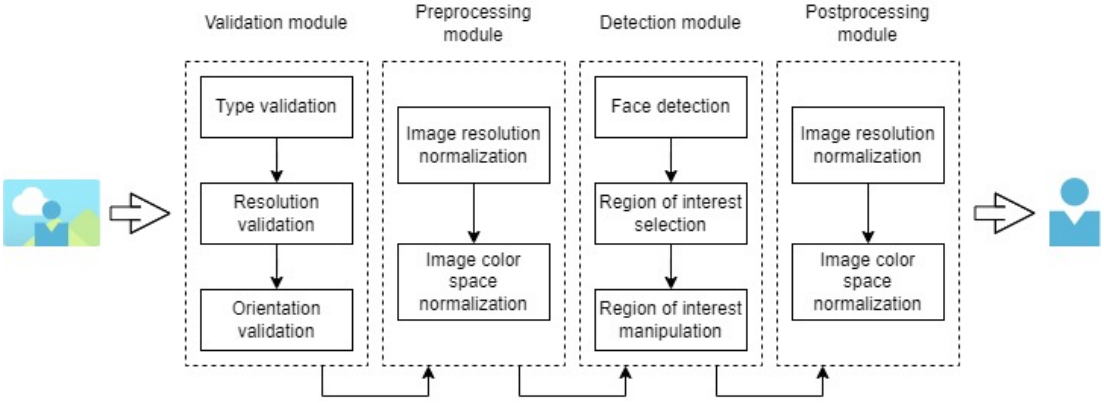


Figure 2: A proposed method for student card photograph creation.

graph creation. The module utilizes FaceNet, an advanced face detection system renowned for its accuracy and efficiency, which incorporates the Multi-task Cascaded Convolutional Networks (MTCNN) architecture [14]. MTCNN is a three-stage deep learning model specifically designed for face detection tasks. It employs a cascaded structure to detect faces at different scales, enabling the accurate localization of facial features within the preprocessed images. The model is capable of handling images with complex backgrounds, variations in lighting conditions, and different facial expressions, making it highly adaptable to real-world scenarios, especially for images of student population. Through the implementation of FaceNet, the algorithm examines the image to ascertain the presence of human face. The success of this step is contingent upon the identification of precisely one face within the image. Any deviation from this, be it a detection of zero or more than one face, triggers an automatic rejection, prompting the immediate cessation of the image processing pipeline. This stringent criterion underscores the commitment to ensuring that only images with a singular, clearly discernible human face proceed through the subsequent steps of the module. The ensuing procedural steps are inherently interconnected and pertain to the Region of Interest (ROI). The ROI designates a specific area or segment within an image frame wherein the object of interest is precisely situated. In face detection applications, the ROI manifests as a bounding box or rectangular delineation encapsulating the identified face within the image. Subsequently, upon face detection, the system directs its focus to this region for subsequent analytical and procedural steps. Given the specific requirements for student card photographs, necessitating the visibility of the entire student head rather than just the face, a recalibration of the bounding box is imperative. This recalibration involves an augmentation of the bounding box by 5% to 10% on the left, top, and right sides, while still adhering to the original image dimensions. Moreover, the lower part is expanded by 15% to encompass the neck portion, ensuring a comprehensive representation of the student.

The concluding module in the proposed methodology is dedicated to image postprocessing. In the antecedent stage, alterations were applied to the image resolution, resulting in reduction. The designated medium for the student card, crafted in collaboration with our partners at AKD, necessitates an image of fixed resolution for optimal printing. The prescribed image size stands at 300×300 pixels. In cases where the bounding box derived from the preceding module yields an image with dimensions below the predefined threshold, upscaling becomes imperative. Employing Enhanced Deep Residual Networks for Single Image Super-Resolution

(EDSR), a state-of-the-art model characterized by a deeper and wider architecture comprising multiple residual blocks, facilitates this process [10]. Given the model's capacity to increase image size by a factor of "x" rather than to a specific resolution, subsequent adjustments are required to ensure the height and width fall within the confines of the 300-pixel limitation. It is imperative that the image remains unstretched, preserving its aspect ratio, thereby necessitating the padding of the image with white pixels to meet the fixed dimensions.

4 An evaluation

Currently undergoing a rigorous testing phase, the system is awaiting the announcement of its production date. The visual representation from Figure 3 provides a demonstrative instance featuring two commonplace student photographs frequently incorporated into the SMS. While both exemplars may be deemed acceptable, the printed image on plastic substrates is susceptible to distortions, blurring, and stretching. Such deformations render the image unsuitable for manual visual scrutiny in the context of student identification.

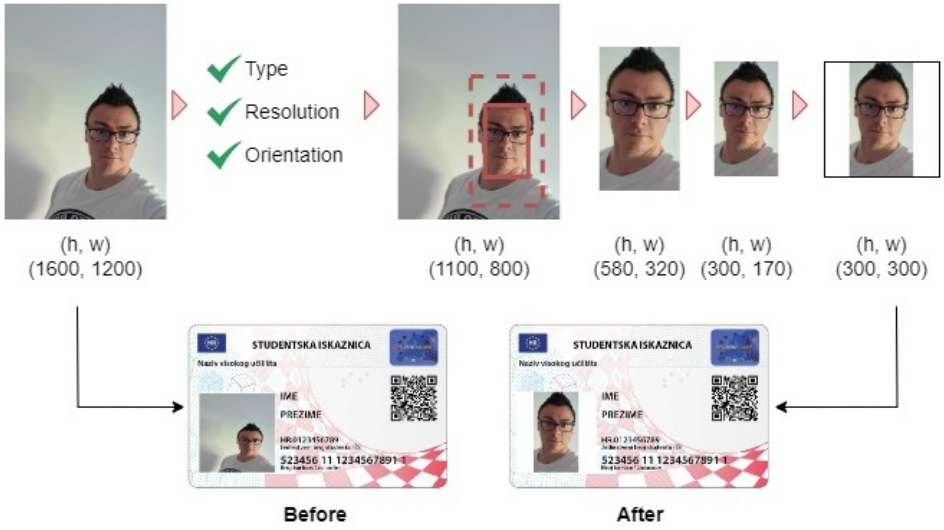
In response to the aforementioned challenge, we propose a Student Photo Quality Enhancement (SPQE) method for augmenting student photograph quality. This proposed enhancement method relies upon the utilization of multiple CNNs, seeking to address and eliminate the issues associated with visual distortions in printed representations of student photographs.

The first illustration, as seen in Figure 3a, delineates a prototypical instance of a "student selfie." The system initiates the validation process for the provided image, encompassing checks for image type, resolution, and orientation through the extraction and analysis of EXIF data. While facial recognition algorithm can operate optimally on high-resolution images, the imperative of computational efficiency mandates a trade-off. Consequently, to prioritize processing speed, the image resolution is intentionally reduced. The FaceNet algorithm successfully identifies a singular face, and the ROI is extracted for subsequent manipulations. The ROI, encapsulating solely the student's head and a portion of the neck, boasts an optimal resolution, requiring only a modest reduction and padding with white space. The resultant image distinctly portrays the student.

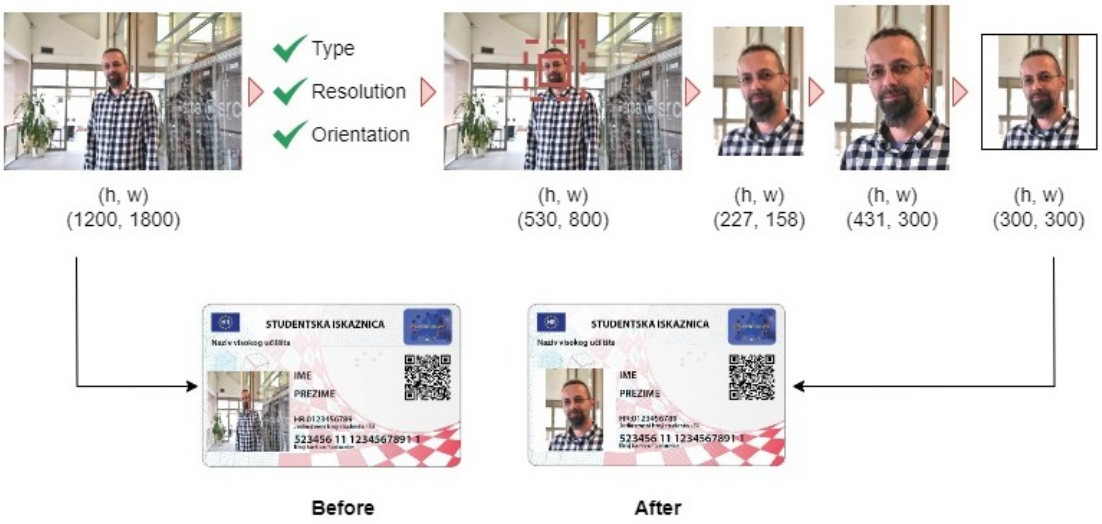
The second illustration, as seen in Figure 3b, involves an image captured at a moderate distance, encompassing a notable amount of background, deemed as image noise in this context. If this image were to be reproduced on a plastic medium, the visibility of the student's face would be severely compromised. Analogous to the preceding example, the image undergoes a validation process. Once again, FaceNet adeptly identifies a singular face, and a ROI is delineated. Diverging from the prior example, the resolution of the extracted ROI proves inadequate, falling below the predefined threshold. Consequently, a scaling-up process is invoked, utilizing the EDSR model, thereby doubling the ROI resolution. Subsequently, the resized ROI undergoes a reduction process and is padded with white space. The outcome is an image that portrays the student and aligns with the predefined quality standards.

5 Future Work

During the testing phase, we have identified areas for enhancement. To augment the quality of student photographs and mitigate potential misuse, the system should incorporate facial expression tracking. Facial Expression Recognition (FER) constitutes a computer vision task focused on discerning and categorizing emotional expressions exhibited on a human face. The objective is to automate the real-time determination of emotions by analyzing facial features such as eye-



(a)



(b)

Figure 3: An evaluation of the SPQE method. The method follows the process from Figure 2. The output image has fixed resolution where height (h) and width (w) have 300 pixels.

brows, eyes, mouth, and others, mapping them to specific emotions like anger, fear, surprise, sadness, and happiness. Potential implementations involve EmotionNet Nano [9] or EfficientNet [15], which can streamline the input spectrum of images. Another avenue for improvement is the complete removal of the background from the image, eliminating any extraneous noise beyond the student's head and neck. This could be achieved through semantic segmentation,

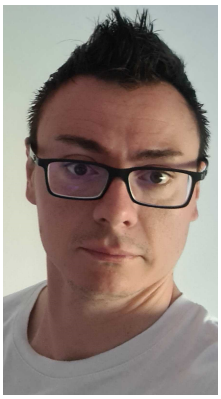
employing architectures like DeepLab [3]. Alternatively, image morphology operations could be applied to seamlessly blend edges into the white surrounding, further refining the quality of the student image.

6 Conclusion

This study provides a detailed overview of the Croatian national HE infrastructure ecosystem, emphasizing a pivotal systems essential for student management and the administration of student cards. Croatia holds the distinction of being the first EU country to implement the ESC at the national level. The student card, as defined by the MSE, is available in both physical and digital formats, featuring cutting-edge technology and compatibility with various services such as restaurants, cafeterias, bookstores, and other on-campus facilities.

While encompassing numerous features, the student photograph on the card holds particular significance for manual or offline student validation. Acknowledging the expanding role of machine learning technologies in diverse domains, we embarked on the development of a novel SPQE method aimed at enhancing student photographs destined for printing on student cards. This method, grounded in EXIF data, FaceNet, and EDSR, has demonstrated efficacy in eliminating extraneous information from the photograph, retaining only the student's head and neck portion. Through this approach, the quality of student photographs undergoes substantial improvement, facilitating streamlined student validation processes.

7 Author Biographies



Filip Bajić is a researcher at the SRCE and a head of the student rights information system and a student cards information system. His current research interests include machine learning, data visualization, and image processing, where he has published many original scientific articles. He is also involved with European Student Card Initiative and other projects whose goal is to improve student standards.

Ognjen Orel is currently the CIO of SRCE. He has over 20 years of experience modelling, building, implementing and maintaining national information systems mainly related to higher education and research. He holds a PhD in Computer science and teaches advanced databases and business intelligence at the University of Zagreb. His research interests are focused on data models, analyses and algorithms, information systems architecture and security. Ognjen is a member and representative in EUNIS and euroCRIS.

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