# System Identification Position Error in Panoramic Radiography: a Review

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## ARTICLE INFO

## ABSTRACT

The professionalism of the radiologist greatly influences the results of radiological images. The quality of panoramic radiography greatly influences accurate clinical diagnosis. The correct patient position is one of the many factors that affect high-quality and accurate panoramic radiography. The process of taking radiographic images causes radiation exposure to the patient, so that when taking radiographic images repeatedly it is very bad for the patient. A review research is needed to reduce radiation exposure by improving the quality of panoramic radiography. This research conducted a literature review by proposing the questions (1) What types of position errors in panoramic radiography have been researched? (2) How is the process of identifying position errors in panoramic radiography that have been researched? The results of the review research showed that the types of position errors in panoramic radiography that have been researched are the head turning, the tongue not sticking to the palate, the chin down, the chin not resting on the support. The process of evaluating position errors in panoramic radiography is mostly done manually, there is only one research that identifies position errors in panoramic radiography automatically using SVM. That there is a great opportunity to create an automatic system for identifying position errors in panoramic radiography to be more precise and time efficient.

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## 1. INTRODUCTION

Panoramic radiography is an extraoral radiography that is often performed in dentistry because it can provide a complete picture of the maxilla and mandible. Panoramic radiography is a radiographic technique for planning dental treatment, diagnosis, and identification. Panoramic radiography has several limitations, including often producing superimposed images of other anatomical structures. In addition, the images produced by panoramic radiography are distorted when compared to the actual size, so it requires special knowledge and skills to avoid misinformation when interpreting images. Errors in radiographic technique can affect the accuracy of the X-ray results, which impacts effective dental treatment planning; one of these errors is distortion of the X-ray image, which often requires repeat imaging.

Patient preparation and instruction errors, positioning errors, exposure errors, digital processing errors, handling errors, and machine operational errors are factors that cause errors in panoramic radiography. In addition, providing appropriate and understandable patient directions is a way to reduce the number of repeat panoramic radiographs. Several researches have shown that many panoramic radiographs obtained are of poor quality. High-quality dental panoramic radiography not only prevents misinterpretations that lead to incorrect diagnoses and treatment planning but also reduces radiation exposure and costs for patients [1], [2]. There is a relationship between radiation exposure due to repeated panoramic radiography and the risk of induced cancer. Therefore, it is very important to perform routine assessment of panoramic radiographic quality as well as

evaluation of common errors related to patient preparation and positioning to prevent panoramic radiographic errors and their associated complications.

In panoramic radiography, there are many background positioning errors that can occur, which can affect the quality of the image and how to understand the results. Here are some of the most common background positioning errors that occur in panoramic radiography: improper head position, improper arm position (positioning the height and distance between the patient and the radiography device), and the patient moving during image acquisition. To avoid positioning errors, radiology technicians must ensure that the patient is in the correct position, receive clear instructions, and perform the examination carefully and with good control of the radiography device.

In dentistry and oral surgery, panoramic radiography is the most commonly used diagnostic imaging method. Panoramic radiography can display the upper and lower jaw teeth and provide complete information for clinical diagnostic analysis [3]. Adequate image quality affects image acquisition performance. The quality of panoramic radiographic images is very important, and it is necessary to perform image acquisition correctly and account for position errors and artifacts that can affect image quality [4], [5], [6]. Positioning errors can be caused by instructor factors when guiding the patient to take photos, and in research [7] Positional errors in panoramic radiography occurred in 31.8% of 1000 panoramic radiography image samples. Positional errors that often occur in research [8], [9] is the tongue does not feel or does not come into contact with the platinum, another error is the patient's head is turned to one side [10].

Panoramic radiography is an important diagnostic tool used to obtain a complete view of the oral structures, including the teeth, jawbone, temporomandibular joint, and surrounding tissues. Poor images can lead to incorrect interpretation, misdiagnosis, or inappropriate treatment planning. Panoramic radiography is a complex imaging technique, requiring precise adjustment of the patient to the equipment. Image distortions such as elongation, compression, or loss of detail of certain structures can be caused by small positioning errors. Identifying the most common types of errors and their impact on diagnostic results requires research. A distortion or artifact caused by a positioning error can obscure important structures or create an inaccurate image. The diagnosis of diseases such as caries, fractures, periodontal disease, or anomalies can be affected by positioning errors. Research can help in the development of protocols or guidelines to reduce positioning errors. Artificial intelligence can be useful in dentistry, with medical datasets helping researchers incorporate expert knowledge into AI to achieve more robust and accurate abnormality detection [11]. This includes benchmark performance analysis of various state-of-the-art systems for dental radiograph image misalignment, image enhancement, and image segmentation using deep learning, as well as an in-depth review of various panoramic dental image datasets alongside segmentation and detection systems. These medical datasets aim to drive the development of AI-powered automatic abnormality detection and classification in dental panoramic radiography [12], improve dental segmentation algorithms [13]-[20], and enhance the ability to determine dental radiograph image misalignment.

Previous researches have shown that the quality of panoramic radiographic images should be high, necessitating further research to improve image quality. Position error analysis in panoramic radiographic images is an additional method for reducing poor image quality. Furthermore, limited research has been conducted on determining position errors in panoramic radiographic images, with most existing studies focusing on tooth numbering or recognition [21]-[24], diagnosis [25]-[27], tooth classification [28], [29], [30], and victim identification [31]-[37]. To reduce misidentification or improper treatment and improve efficiency, previous studies on position error evaluation in panoramic radiography need to be reviewed. This is because research has shown that the process of analyzing position errors in panoramic radiographic images is still performed manually, requiring both precision and time. The contribution of this research is to review articles related to the automation of position error detection in panoramic radiography using AI.

## 2. RESEARCH METHODS

This research conducted a literature review related to positional errors in panoramic radiography. Data in the form of articles that have been published in journals or seminars with the theme of positional errors in panoramic radiography. Data was taken from Google Scholar and ScienceDirect. This research conducted an article search based on the questions: (1) What types of positional errors in panoramic radiography have been researched? (2) How is the process of identifying positional errors in panoramic radiography that have been researched?

## 3. POSITION ERRORS IN PANORAMIC RADIOGRAPHY

Research related to the identification of positional errors in panoramic radiographic images that is highly relevant is:

1).    One of the factors that causes failure of panoramic radiography is incorrect patient positioning.

2). From the analysis of panoramic radiographic images in the dental radiology unit and general radiology department, 54.6% of them contained patient positioning errors and 47.9% of them contained preparation errors from staff and patients.

3). Mistakes in the position of the tongue not being on the platanum, placing the chin too low are the most common mistakes in panoramic digital radiographs at UPF Radiology Dentistry RSGM Faculty of Dentistry, Airlangga University.

4). Patient positioning errors have a rate of 99.19% which often occurs at the Special Dental and Oral Hospital in South Sumatra.

5). Of the 1000 panoramic radiographic images, the most common position error was the position of the tongue against the palate at 69.5%, and the rare error was the patient moving during image acquisition. Based on image quality, 22.4% had good quality, 66.4% could be used for diagnosis, and 13.2% could not be used [1].

6). Of the 2629 panoramic radiographic images, 32.8% of the images had good quality/no errors, 77.2% had more than one position error. The most common error was placing the tongue against the palate [2].

7). Of the 200 panoramic radiographs, 36% showed no positional errors, and 64% showed positional errors. The presence of radiolucency obscuring the maxillary tooth roots was the most common error observed at 33%. The second most common errors were artifacts, reflected images, and shadows at 17%. In addition, errors on the radiographs at 15.5% showed errors in the patient's head being too high; errors in the vertebral overlap in the lower anterior region due to slumping; and errors in the patient's position being too far back. The patient's position being too forward was the least common error.

8). Factors that affect the quality of panoramic radiographic images are the position of the spine, metal artifacts and the position of the patient [4].

9). Of the 300 panoramic radiographs, and 52 images were error-free (good quality 17.3%). As many as 82.6% (248 images) had position errors. There was only one position error of 205 images, 35 images had two position errors, and 8 images had three position errors. With images that have position errors, it can reduce the value of medical diagnosis [5].

10). Of the 1000 panoramic radiographic images, 68.2% had good quality, and 31.8% had positional errors. Positional errors included horizontal errors (7.3%), patient movement (6.4%) and patient tongue position (6.2%) [7].

11). Of the 1782 panoramic radiographic images, only 11% were correct without errors, and 89% of the images had positional errors. The most common error was positioning the tongue against the palate at 55.7%. The least common error was patient movement during image acquisition (1.6%). Of the 1782 panoramic radiographic images, 11% were of good quality, 64.1% could still be used for diagnosis, and 24.9% were of very poor quality and could not be used.

12). The error that occurred in the 1990 panoramic radiographic images was that the tongue did not touch the palate (94.8%). The error in each image varied, with only one error of 48.4%.

13). Of the 3788 panoramic radiographic images, 56.4% (2138 images) had good quality and no errors, 43.6% (1650 images) had positional errors. The most common error was that the tongue did not touch the palate, and the rare error was that the patient moved during image acquisition [8].

14). A total of 563 panoramic radiographs (34.3%) had two errors, the most common error being that the patient did not attach the tongue to the palate. There are fewer radiographic images that have good quality than those that cannot be used [9].

15). Of the 500 panoramic radiographic images, 86 images were of good quality, and 414 images had more than one position error. The most common position error was turning to one side, and the least common error was patient movement [10].

16). Conducting an evaluation of the quality of panoramic radiographs and the frequency of patient position errors. The images used in the research were 312 panoramic radiographs, and the results of the research showed that 98.78% of the images contained position errors with the highest type of position error being placing the tongue on the palate at 49.68% [38].

17). The frequency of positional errors was analyzed from 1904 panoramic radiographs. There were 79% positional errors in the panoramic radiographs, and 21% of the images were of good quality. The most common error was that the tongue did not touch the roof of the mouth.

18). This research evaluated positional errors in panoramic radiographic images. Of the 500 panoramic radiographic images, 5% had no errors, and 95% had one or more positional errors. The most common error was turning to one side, and the rare error was patient movement during radiographic image acquisition.

19). In an analysis of 2000 panoramic radiographs, it was found that 81.16% showed errors. The dominant error identified was misplacement of the tongue against the palate, which accounted for 34.75% of cases [39].

20). Failure to position the tongue against the palate was the most common cause of errors in 771 panoramic radiographic images. Types of errors evaluated included "head turned", "tongue not against palate", "chin down", "chin not resting on support", "patient movement during exposure", and "artifacts" [40].

21). Of the 2418 panoramic radiographs reviewed, 2354 (97%) had no errors, and 64 (3%) showed positional errors. Failure to position the chin with the tip high was the most common positional error reported on the radiographs (56.02%). The least frequently reported positional errors were movement and shadowing (1.15%) [41].

22). Of the 480 panoramic radiographs reviewed, 100 (21%) were free of positional errors, and 380 (79%) had multiple positional errors. Patients who wore nasal pins were 8.3%. Failure of the patient to position the tongue against the palate was the most common positional error (62.5%). 41.6% of the incorrect radiographs had more than one positional error. Of the radiographs evaluated, only 21% were considered excellent, 64.5% were diagnostically acceptable, and 14.5% were unacceptable.

23). 460 radiographs were evaluated for twenty error categories. 37.61% of the evaluated radiographs had no errors. Shadowing of the palatoglossal air space above the tongue due to the patient not lifting the tongue to the palate (46.30%) and superimposition of the hyoid bone with the mandible (26.30%) were the most common errors found.

24). Of the 1,287 radiographs, 96 percent had errors, and the remainder were usable for clinical diagnosis. The most common error was that the tongue did not touch the hard palate.
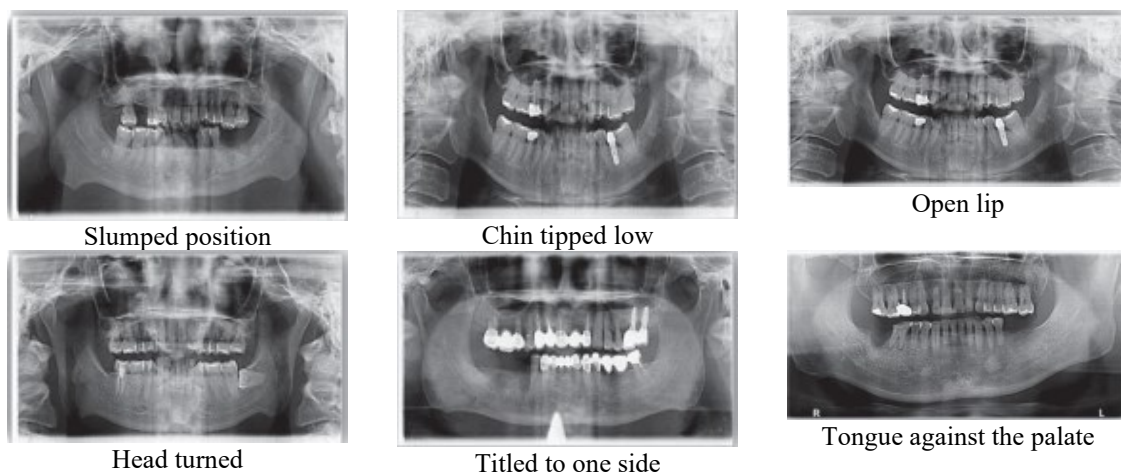
## 4. AUTOMATIC IDENTIFICATION ON PANORAMIC RADIOGRAPHY

Research that performs automatically in panoramic radiography is:

1) Applying SRCNN (super-resolution convolutional neural networks), SRGAN (super-resolution generative adversarial network), and U-Net models to improve the resolution of panoramic radiographic images. The most significant method in improving the quality of radiographic images is SRCNN. Fig. 1 shows the results of the research that automatically improves the quality of images [42].

2) Another automated research is to identify positional errors in radiographic images using the Convolutional Neural Network (CNN) method. Creating a model to classify positional errors from panoramic radiographic images. Classification into six types, namely hunched position, low chin, open lips, head turned, head tilted, and tongue stuck to the roof of the mouth. The panoramic radiographic images used were 552, Fig. 2 is the type of positional error in panoramic radiographic images. Fig. 3 is the stage in detecting positional errors in panoramic radiographic images with SVM [43].

3) Applying SVM machine learning for classification and detection of dental restorations. Fig. 4 is an example of the results of dental restoration detection with SVM. There are six types of dental restoration detection in the research, namely Amalgam filling, Composite filling, Crown, Dental implant, Root canal treatment core [44].

4) Applying deep convolutional neural networks (CNN) to detect apical lesions, with three types of classification, namely: undetectable apical lesion, widened periodontal ligament (uncertain apical lesion), and clearly detectable lesion (certain apical lesion) [45].

5) Creating a Deetal-Perio method to determine the severity of periodontitis on panoramic radiographs. The Deetal-Perio method segments teeth with Mask R-CNN, and then the segmentation results are calculated to determine the severity of periodontitis [25].

6) Evaluating the performance of Deep Learning for dental implant classification, and periodontists. Fig. 5 shows six types of implant classifications determined in the system with the Deep Learning method [46].

7) Performing tooth detection and classification using the CNN method. 591 panoramic radiographic images were subjected to object detection using Faster R-CNN. Fig. 6 is an example of the results of tooth detection [22].

8) Developing an automated model for mandibular fracture identification and detection in panoramic radiographs using Faster R-CNN, and YoloV5. Fig. 7 is the result of mandibular fracture classification using the DenseNet-109, and ResNet-50 methods, object detection (box to determine the mandibular fracture section) using Faster R-CNN, and YoloV5 [47].
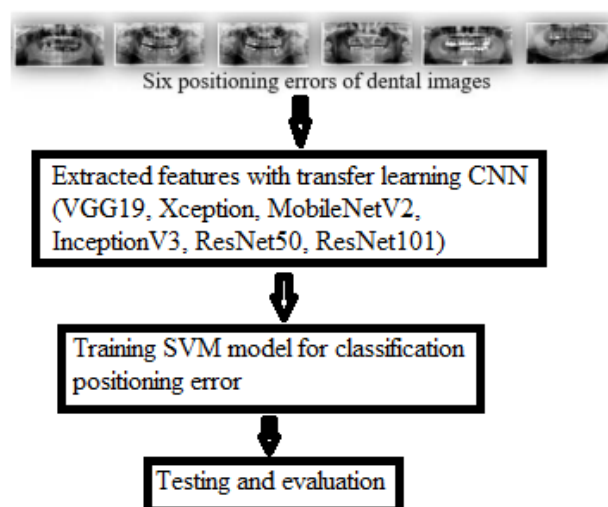
Original image      SRCNN output      SRGAN output      U-Net output
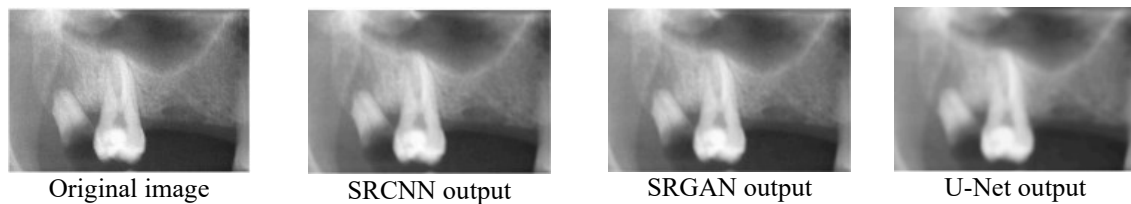
**Fig. 1.** Automatic image enhancement results [42]

9) Conducting analysis of the denti.ai website to determine metal restorations (MR), resin-based restorations (RR), endodontic treatment (ET), Crowns (C) and Implants (I) using the AI method. Figure 8 is the result of the denti.ai website in determining dental diagnosis [48].

10) Building a segmentation and classification system for shallow caries, moderate caries, and deep caries types with deep learning called CariesNet. Fig. 9 is the result of caries segmentation with various deep learning methods [49].

11) Creating a classification and segmentation system for cysts and tumors in the jaw using a deep learning model. Fig. 10 is the result of segmenting tumors in the jaw [50].

12) Creating an automated screening model to determine ectopic eruption. Identifying eruption anomalies in radiographs is highly dependent on the radiologist's experience, so an automated model is needed to assist dentists in their clinical tasks and be time efficient [51].

13) In general, research on the use of panoramic radiographs for identification has revealed that the chin is a more sexually dimorphic and heterogeneous anatomical structure than the symphysis [52].



Slumped position      Chin tipped low      Open lip

Head turned      Titled to one side      Tongue against the palate

**Fig. 2.** Types of position errors in panoramic radiographic images [43]



**Fig. 3.** Stages of automatic identification of position errors in panoramic radiographic images [43]

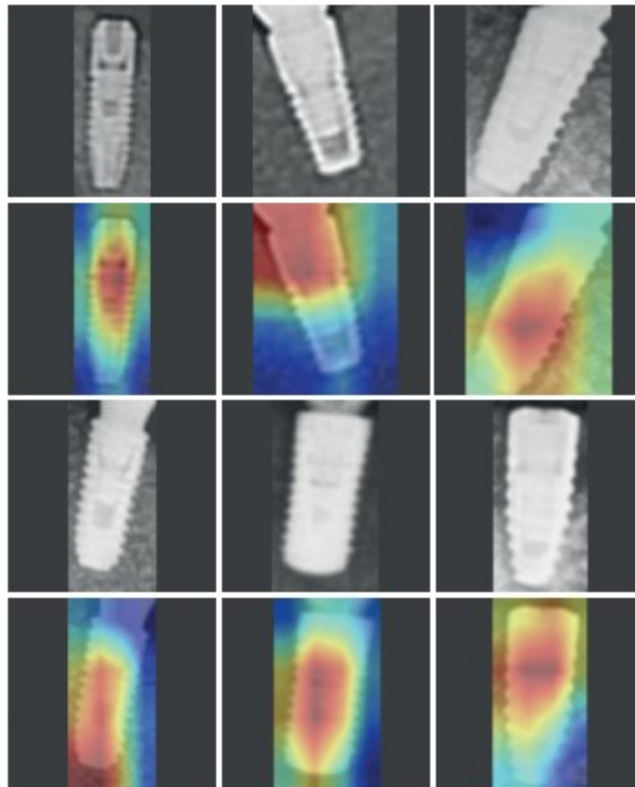**Fig. 4.** Restoration Detection on Panoramic Radiography [44]



**Fig. 5.** Types of implant classification systems [46]
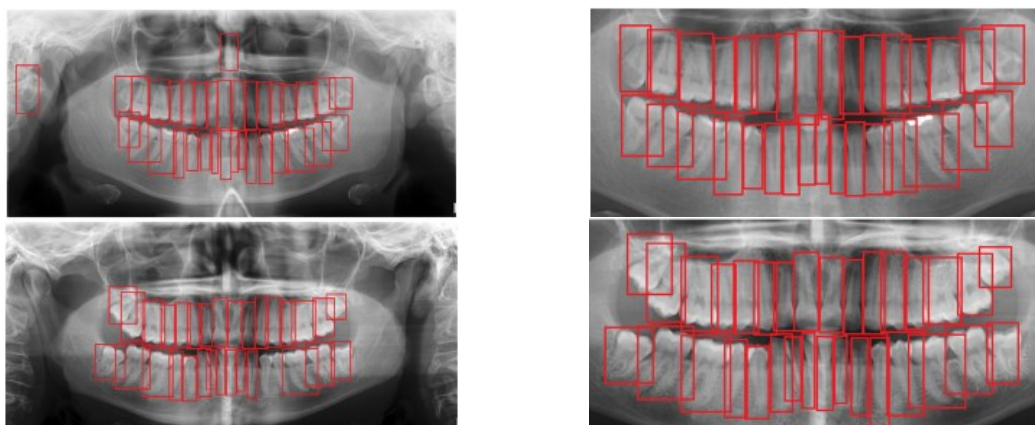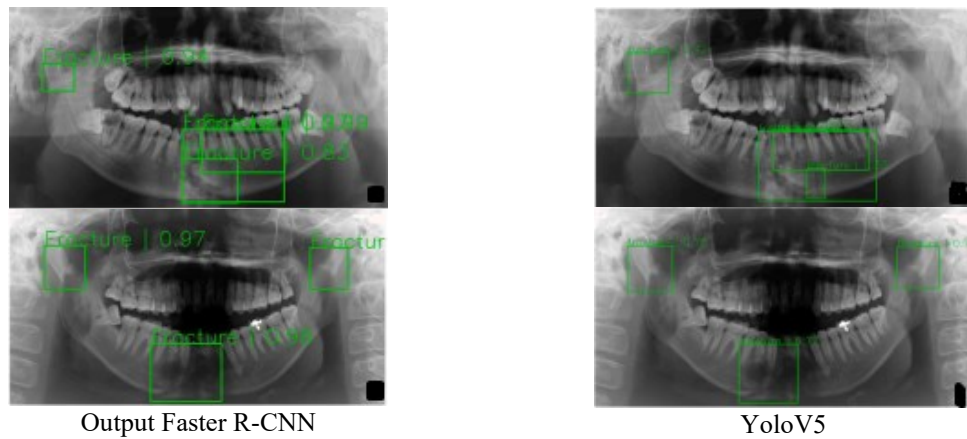


**Fig. 6.** Teeth detection results with Faster R-CNN [22]

Output Faster R-CNN            YoloV5

**Fig. 7.** Mandibular fracture detection object results [47]
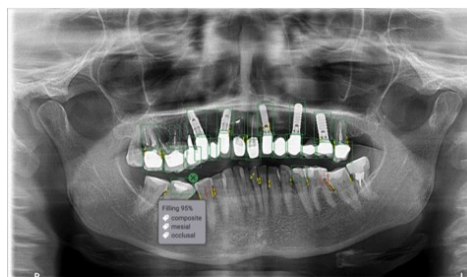


**Fig. 8.** Denti.ai website diagnosis results [48]



Original image

CariesNet      PraNet      U-Net      DeepLab V3      Res-U-Net

**Fig. 9.** Caries segmentation results with deep learning [49]
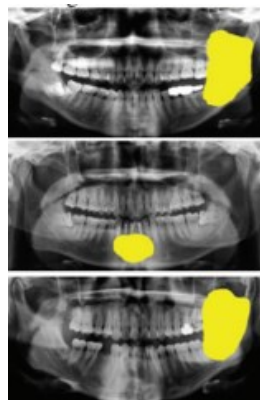


**Fig. 10.** Tumor segmentation results with deep learning [50]

## 5. CONCLUSION

This research conducted a review related to positional errors in panoramic radiography. The proposed questions are (1) What types of positional errors in panoramic radiography have been researched, and the results of the review indicate that the types of positional errors that have been researched are (a) The position of the tongue is not on the platanum, or the tongue does not stick to the palate, (b) The chin is lowered, or the chin does not rest on the support, (c) The head is turned. The second question (2) How is the process of identifying position errors in panoramic radiography that has been researched, and the results of the review are the process of identifying position errors in panoramic radiography is done manually by radiologists, and the automatic process for identifying position errors is only one research with the transfer learning method (VGG19, Xception, MobileNetV2, InceptionV3, ResNet-50, ResNet-101) for feature extraction, and identifying position errors with the SVM method, with six types of position errors, (a) slumped position, (b) chin tipped low, (c) open lip, (d) head turned to one side, (e) head tilted to one side, and (f) tongue against the palate. The research suggestion is to create an automatic system with the deep learning method to identify position errors in panoramic radiography.

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