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# FORENSIC RADIOLOGY: AN INTELLIGENT METHOD OF AGE AND GENDER ESTIMATION FROM X-RAY SCANNED BONES IMAGES USING CONVOLUTIONAL NEURAL NETWORKS

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**Abstract**
*Determination of identity is always the most demanding aspect of a person, when only bones are left. Identity can be lost due to natural disasters and incidents. Police departments and other law enforcement agencies engage the forensic department to estimate the age and gender when such an event occurs. In this study, a comparative identification method is being utilized on panoramic dental X-rays through the segmentation of morphological features. Which will be extracted, and our model will be trained using DCN by comparing the atlas and cranial measurements for age and gender estimation, respectively. The proposed model is trained and produced a 98% accurate result during the test phase with 840 images of different age and gender groups. This study is being introduced for the very first time in Pakistan. It will help police, forensic, and other law enforcement agencies to make faster, possible their investigation process in economical. It will help to reduce the total amount of DNA.*

## INTRODUCTION

Identification of human beings has always been a curiosity, a need, a requirement for living or dead, becomes essential for those who need to process or investigate for different purposes the living or in the form of human remains without any clue, belongings, proof, or any type of identification (Gilanie et al., 2018a). In case of death, the human body loses its complete or partial identity, which can be seen in Figures 1 and 2, respectively, due to the following reasons: fire, being dumped inside a grave for a long period, a major accident, and being crushed into pieces (Rashid et al., 2024).

**Figure 1: Complete Human Remains**

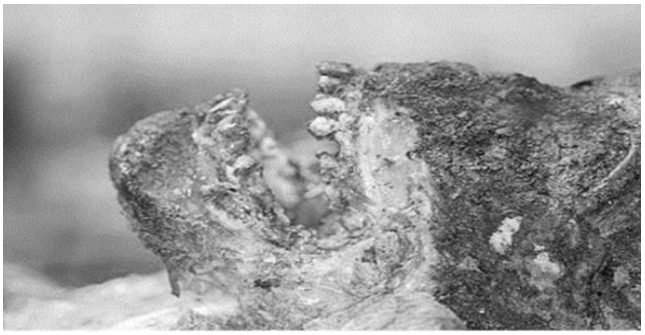


**Figure 2: Partial Human Remains**

These identity facts include face, hair, fingerprint, skin color, eye retina, or personal belongings for living persons (Bajwa et al., 2018). Identification becomes most difficult when dead bodies or living people have lost fingerprints and other physical features due to decomposition of the human body or due to any incident (Khera et al., 2023). There are so many incidents where the identity of a human being is lost, but becomes essential for the investigation process (Batool et al., 2025, Akhtar et al., 2025). I would like to share the most tragic incidents, natural disasters, and crimes (Ghani and Gilanie, 2023) where human identification was completely lost, but it was required to find identification proof for all of them in Pakistan (Ghani and Gilanie, 2023, Wazir et al., 2022).

In a crucial incident that happened on 25th June 2017, at Ahmedpur city, an oil tanker turned turtle, resultantly, 50000 liters of oil spreading (Ullah et al., 2022) along the road (Sajid et al., 2025). A mob of the nearest villagers gathered to collect the petrol, but suddenly, the petrol caught fire, and an explosion occurred in a few moments. 219 people were burned, and many of them were injured in this tragic incident, which can be seen in Figure 3 (Wikipedia, 2017).

**Figure 3: Oil Tanker Incident Ahmedpur**

All dead bodies lost their identity and turned into a bunch of bones, which can be seen in Figure 4. Over 120 dead victims, who were beyond recognition, were buried in a mass grave. The Government of Pakistan announced the amount of Rs 2 million to each parent/guardian of all people (Veling et al., 2019). To claim this amount, more than 10000persons from different families appeared as claimants (Gilanie et al., 2021b). Here again problem was the identification because only bones were available, which can be seen in Figure 4 (Wikipedia, 2017).

**Figure 4: Human Remain After Oil Tanker Incident for Identification**

In another incident in the city of Kasur, the human remains of three children were found on 17 September 2019, reported by ARY News Channel (Gilanie et al., 2025d). The screenshot can be seen in Figure 5. It was very threatening for the rest of the country that human remains of children were found who were dumped (Attique et al., 2012) partially in different geological areas that are adjacent to dunes in Choniyan, district Patoki (Ahmed et al., 2020) .


**Figure 5: Human Remains Reported on Private News Channel**

Who were brutally raped, killed and dumped into hidden grave. Identification was required in this case to identify human remains as well as to investigate the remains (Gilanie et al., 2021d). The police assumed that these were the remains of three missing children, Salman, Muhammad Imran, and Muhammad Faizaan, as they received the report of missing children in Kasur two months ago (Ullah et al., 2023a), and the police are still searching for those children in the surroundings (Gilanie et al., 2025e). The children can be seen in Figure 6.

The identification of these human remains was done with the help of DNA (Gilanie et al., 2013), but the question was who killed and raped them? To whom DNA test be done? Will it be done for the people of the whole city? Because no one can be hanged based only on assumptions (Ullah et al., 2023b) or clues. Another issue is that, still, in Pakistan (Gilanie et al.,

2025c). No DNA Database is available yet (Ahmed et al., 2021).


**Figure 6: Children Abused in Kasoor**

In October 2005, A 7.6 magnitude earthquake with a maximum Mercalli intensity of VIII (Severe) struck Afghanistan, Tajikistan, and Chinese Xinjiang, as well as the surrounding region (Gilanie et al., 2019b). There were 75,000 fatalities casualties which can be seen in Figure 7. (Wikipedia, 2005).

**Figure 7: Natural Disaster, Earthquake in October, Kashmir**

Many dead bodies lost their identity and /buried temporarily. The officials adopted the methods of matching the belongings of dead bodies with information provided by claimants. No autopsy, X-Ray, fingerprints, and DNA( deoxyribonucleic acid ) were performed for identification, ICRC (2020). Management of dead bodies after disasters: a field (Aartsen et al., 2017).

From 2001 to 2010, in blasts and suicide attacks, a total of 63898 people, of whom 22657 were civilians, 7127 security personnel, 34114 terrorists/insurgents, lost their life as well was many of them lost their identification (Terrorist, 2020). A horrible scene can be viewed in Figure 8 (Gilanie et al., 2022a). Terrorists/insurgents and the victims also lost their identities (Gassebner et al., 2020).

**Figure 8: Bomb Blast / Suicide Attack**

In all these (Gilanie et al., 2022a) incidents, the claimants of the accused people identified their loved one with their belongings like watches, rings, ID cards (Gilanie et al., 2025f), dresses, and shoes. No DNA or other identification methods are applied here for proper identification (Ullah et al., 2018). The belonging identification process in be seen in Figure 9.

**Figure 9: Belongings of Martyrs in Bomb Blast**

On October 31st, 2019, another incident occurred where a train caught fire in its three bogies. 73 people lost their lives in this train inferno, which can be seen in Figure 10 (Joshi, 2020).

**Figure 10:** Fire Incident in a Train

All of them were burned alive, and at the end, no one was identified. (Naveed et al., 2024). The human remains can be seen in Figure 11. The claimants were demanding government give the bodies of their loved ones, but here again, identification became a major issue, and here, gender and age also needed to be identified (Gilanie et al., 2024). "Family of Pakistan train fire victims struggle to identify loved ones".

**Figure 11: Human Remains after Burning Train**

In another incident, 11th September 2012, about 250 workers of a factory named "Ali Enterprises" were burnt alive in Baldia Town Karachi, as shown in Figure 12.

**Figure 12:** Fire Incident in Baldia Town Karachi

The unidentified of the 17 victims is unlikely to be resolved. Neither is the case (Gilanie et al., 2025a). The decomposed bodies of the 17 victims were buried unidentified, five months after the tragedy (Gilanie et al., 2025b, Ullagaddi and Raju, 2017). The case has lingered on, with the culprits unidentified, much like the victims. The plane after the crash can be seen in Figure 13. In a major plane crash on 20th April 2012, in which 127 passengers died on the spot, here again, the issue was the identification of the passengers.

**Figure 13:** Plane Crash in Islamabad

All the dead bodies were completely unidentified able and here again, the identification was done with the personal belongings of the 118 passengers (Trang et al., 2019). While 09 passengers were identified with the help of DNA sampling after 6 months, it could have been done in a few hours if the DNA database were available (Gilanie et al., 2025b). The conditions of the cashed plan can be seen in Figure 14, clearly showing that no human body remains as a single object (Latif et al., 2025), but instead as small chunks of muscles, bone, and burned skin (Singh et al., 2019).

**Figure 14:** Plane Crash at Islamabad

In another tragic incident of a plane crash on 22nd May, 2020, where 98 passengers lost their lives on the spot, and one lucky person survived (Sharma et al., 2022). Here again, the issue was the identification of dead bodies, as shown in Figure 15. Wrong identification of a plane crash victim's body creates issues after burial, even after the DNA was performed, but the issue was the unavailability of DNA profiling (Saleem et al., 2021b).

**Figure 15:** Plane Crash at Karachi

Now I would like to share the details about age identifications required for different purposes in a living person, called chronological age, where there is no documentary proof of age, or the proof is forged (ULLAH et al., 2024b).

Age determination of children and its method being practiced in Pakistan for different purposes (Gilanie, 2013).

Age assessment is required for an Asylum Claim (Ullah et al., 2012). Each year, refugees come to Europe. Almost 4 % of them are, according to their declaration, minors. Since the controls for conceding or denying entry into the nation are different between minors and adults, governments are eager to discover the age of the refugee seekers who claim to be minors (Gilanie et al., Gilanie et al., Ullah et al.). The assistance of doctors is sought to determine the age of these people (Saleem et al., 2021a). Date of birth and chronological age but moreover, organic age, are determinants of how people can take an interest in (Malik et al., 2021), or are treated by, the society in which they live (Gilanie et al., 2021c). The truth that proof of age is crucial to the realization of rights and needs in society is recognized (Sauer et al., 2016).

The basic issue of characterizing a child and adjusting the crucial issue of characterizing a child and adjusting the description to the UNCRC leftovers an objective indeed 25 years after Pakistan confirmed the UNCRC (Ullah et al., 2023c). The Visualization varies from law to law and province to province, as outlined in the following table:

- 18 years for boys and 16 years for girls in the Child Marriage Restraint Act 1929 (applicable in KP and Baluchistan) and the Punjab Marriage Restraint Act 2015
- 18 years for boys and 16 years or puberty for girls in Zina Ordinance 1979
- 16 years in the Sindh Children Act 1955; the West Pakistan Vaccination Ordinance 1958
- 18 years in the Sindh Child Protection Authority; the KP Child Protection Welfare Act 2010
- 15 years in the Factories Act 1934 and the Mines Act 1923
- 14 years in the Shops and Establishment Ordinance 1969 (an adult being 17 years)
- Employment of Children Act 1991, a person between 14 and 18 years is an 'adolescent')
- 18 years in the Juvenile Justice Ordinance 2000; Punjab Destitute and Neglected Children Act
- 2004; KP Child Protection Welfare Act 2010; Sindh Child Protection Authority 2011; Sindh
- 13 years Domestic Violence (Prevention and Protection) Act 2013; Sindh Child Marriage Restraint Act 2013
- The parallel Federal Shariat Court system in Pakistan, which defines puberty as the end of childhood

The most crucial need of accurate age determination is in criminal offences to claim Juvenile special remission in death penalty, judicial penalties, punishments, delays in judgments, type of prison (Criminal or Juvenile), and bail before or after arrest. Here I would like to cite some references where age was claimed to breach the judgment of the "Death Penalty" for an act of criminal offence

A case (Appellate Jurisdiction) CRIMINAL SUO MOTU REVIEW PETITION NO.84 OF 2018

(On appeal from the judgment dated 13.06.2002 passed by this Court in Criminal Appeal No.378 of 2001.) INCRIMINAL APPEAL NO.378 OF 2001 AND CRIMINAL PETITION NO.947 OF 2018. (On appeal against the order dated 05.09.2018 of Lahore

High Court, Rawalpindi Bench, Rawalpindi in Criminal Revision No.118 of 2015.) Hearing was on 28.01.2020 being done in THE SUPREME COURT OF PAKISTAN, whereas the petitioner claimed to be a Juvenile. The Trial Court convicts the petitioner and sentences him to death. The accused, aged 15 years 9 months 19 days at the time of the offense, the defendant was considered a juvenile, meaning he was less than 18 years of age. Thus, they deserve to be granted special remission, within the contemplation of enabling provisions of Ordinance and Government Order; that the petitioners produced sufficient reliable oral and documentary evidence to prove their date of birth to prove them to be juveniles at the time of the commission of the offence. In rebuttal, the worthy counsel for the complainant and the State counsel, vehemently assailed the contentions of the worthy counsel for the petitioners, asserting that the review of the judgment confirming the death sentence awarded to the petitioners could not be reopened at this belated stage and that the petitioners had intentionally delayed the proceedings and, thus, should not be rewarded for their abusing the process of the law. The crucial ossification test to determine

In another case (Criminal Petition No.251-L of 2020 (Against the order of the Lahore High Court, Lahore Dated 24.02.2020 passed in Crl. Misc. No.8158-B of 2020) of THE SUPREME COURT OF PAKISTAN was hearing as on 20-05-2020 Sections 7 and 10 (7) of the Juvenile Ordinance:

The first bail application of the petitioner was dismissed on merit by both the courts below on 29.08.2018 and 26.12.2018, respectively. Thereafter, a charge was framed against the petitioner

On 8.04.2019, and the petitioner on 22.04.2019, moved an application seeking a declaration of his juvenility at the time of the crime, having been born on 01.01.2001, according to Form "B"

Maintained by NADRA. He also moved an application on 24.4.2019 for an ossification test. After examining the birth certificate issued by NADRA, the medical report, and the ossification test, the Determination of age (Rubab et al., 2022). If a question arises as to whether a person is a child for this Ordinance, the juvenile Court shall record a

finding after such inquiry, which shall include a medical report, for determination of the age of the child.

The most famous case of murder Shazaib Khan by Sharukh Jatoee. In this case, the accused claimed that he was underage and should be sent to a Juvenile. His educational certificates show his birth in 1993 and CRC (Child Registration Certificate) and passport showing that he was born in 1995. Finally, the court decided that an ossification test should be done, felt some X-rays of the wrists, shoulders, and hipbones (Rashid et al., 2024). The ossification test report was fake, and the doctor misled the court and gave an edge to a criminal. It happens only due to the absence of the use of technology (Shoro et al., 2020).

In all the above-mentioned scenarios, identification was the major problem. In the future, when only bones are left, how will identification be performed? Who will do the identification?

The police department is reported first when a fully or partially decomposed dead body is found. They refer the found materials to the doctor for assessment of the age with the help of intramembranous, endochondral, and wrist tests, with an assessment difference of two years (Rao et al., 2021). This is only used for the identification of individuals aged greater than 18 and above (FIDH, 2020). When doctors give reports/results, they start further investigation and present the opinion in court or other law enforcement agencies. The local doctor does not do gender identification. This method is also being performed only on demand from the claimants. If any claimant insists and affords, then they refer the case to the forensic department for a DNA test as well (Rajbongshi et al., 2021).

On the darker side, when no claimant is found in such cases, the police department hands over the bones to the municipal corporation department, and the case is closed. The insurgent got relief indirectly. The forensic department always caters to such issues daily, when they get all the data from the crime scene (Rahaman et al., 2023). Investigation commences in three dimensions, i.e., identification of the murdered, cause of death, and identification of the accused (Rafiq et al., 2021).

The forensic department uses pathological methods as well as radiological methods in the investigation.

The purpose of this research activity is to provide a method for the identification of a dead body to assist the forensic department directly, while police, courts, law and order, and enforcing agencies indirectly. There are many methods (Pham et al., 2020) that can be exercised by the forensic department, which includes fingerprints, ossification of bones through X-Ray or Computed Tomography (CT), and deoxyribonucleic acid (DNA) (FIDH, 2020). Each of these methods has some limitations regarding its accuracy and availability. DNA has always proven to be the best one among these.

For instance, if 10,000 people are claimants of a body, would it be possible to perform DNA of each of the claimants in a reasonable time? Will each claimant afford the DNA fee? it is not possible to perform DNA of each parent claimant, who claims for the dead person. Because there is only one lab available for DNA tests in Punjab for the huge volume of population of over 150 million. This problem can be solved if the age and gender of the body are identified initially (Herbert, 2006, Prabu and Chelliah, 2022).

### 1.1 Research Motivation

Being a father of a daughter, I got shocked when heard rape and murder cases of Zanib Ansari on TV. Three other cases in the same area, Faizaan, Salman, and Aali Hussain. Only Faizan's body was recovered in full, whereas the two other bodies were found in a decomposed state (only Skulls were found). The bodies were recovered from dunes in the Chunian Industrial Area of Kasur district (Chughtai, 2018).

I thought, "I should do something against such criminals, who raped the children and kill them brutally and dump the dead bodies and wait for the decomposition". The culprits thought nobody would get a clue from the left bones if found, and they would continue their criminal activities (Naveed et al., 2024). However, not always, the proposed system will help the police, forensic, and other law enforcement agencies to initial identification of age and gender before doing DNA. This data can be matched when they are with missing children and will be helpful for claimants for further DNA testing.

### 1.2 Problem Statement

There are many techniques used for the identification of age and gender using pathological, radiological, CT (Computerized Tomography), and DNA. Currently, age and gender estimations are being performed separately with different parts of the body X-Ray to provide identification as evidence in courts (Nagaraju et al., 2020). Currently, no solution is available to determine both age and gender except CT and DNA, but both are costly and not possible for all cases here in Pakistan due to a lack of forensics laboratories and least data dataset available for DNA matching (Janjua et al., 2018). The aim is to provide an easy, economical, and possible single method with panoramic dental X-Ray for the determination of age and gender with accurate results (Asghar et al., 2017, Wazir et al., 2022).

### 1.4 Research Questions

Q1. Can dental X-rays be used to estimate the Age & Gender of humans?
Q2. Can dental X-rays provide clues to estimate race, height, or biological identification biomarkers?
Q3. Can computer vision extract hidden features present in dental X-rays for biological identification biomarkers?

### 1.5 Research Objectives

I. To provide an intelligent system that will facilitate forensic departments and law enforcement agencies to determine age and gender from the analysis of dental X-Ray images.
II. To provide an intelligent system that will facilitate the radiology department through visual clues, having patterns of race, height, etc.
III. To provide a computer vision-based model that could reveal hidden patterns present in dental X-rays for the estimation of biological biomarker identification.
IV. To reduce the population size for DNA.

### 1.6 Research Gap

There are several gaps found in current research, like fewer datasets, quality of images is not up to the mark. Methods applied for detection are notaccording to standardized benchmarks. Mostly only one identification feature is obtained, either age or gender, while many other features can be extracted, like race, bite marks, pre-mortem, and anti-mortem. Basic image processing techniques are missing while processing the initial datasets. Another major deficiency is the less accurate result.

### 2.1 Background

#### 2.1.1 Categories of Human Growth Sorts

Spontaneous human distinguishing proof frameworks that identify human age from different aging highlights are an exceptionally challenging task. Maturing highlights are the essential data carrier that redirects parcels of properties of human body parts from birth to old age. Maturing highlights are separated into biological and natural maturing highlights. Biological and natural maturing highlights are utilized in various applications of medicine and scientific research, which can be seen in Figure 16. It was established that confront was regularly utilized as unmistakable body portion, other than this; the femur, clavicle, and hand-wrist are all short and long bones (Saher et al., 2024), cranium bones and dental examination seem moreover be utilized for human characteristic recognition for higher accuracy (Amjad et al., 2021, Gilanie et al., 2022b). Biological maturing highlights include teeth, discourse or voice designs, stride, race, signature elements, and hand geometry. These maturing highlights incorporate highlight descriptors (Khera et al., 2023) such as alteration in shape in generally appearance, coming about from drooping, alteration in color, coming about from maturing, and alteration (Iqbal et al., 2022).

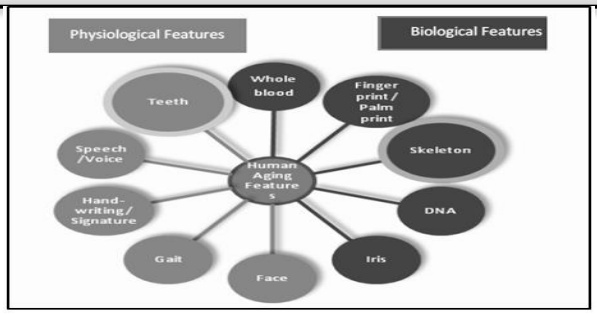



**Figure 16:** Human Identification Feature

**There are their major methods of age and gender estimation**

1. Morphological
2. Biochemical
3. Radiological

For instance, the left hand wrist, the femur bone (KC, 2019) and skull (Ubelaker and Longeway, 2019) can be used for age assessment, while the pelvic bone can be used to determine gender only (Li et al., 2019).

**2.2 What Bones Can Tell Us?**

The whole story about research is "What Bones Can Tell Us? "

When human remains are found or any case demands investigation, it raises many questions about it, like

Are these bones of human beings or animals?

Are these bones of a single person or multiple people?

What was the individual male or gender, age, and race?

How he or she killed, murdered, poisoned, committed suicide, natural disaster or any other incident?

What was the age of the accused at the time of death?

What were the dimensions of the accused's body, like height, weight, and physique?

How can facial features be reconstructed?

A single answer to all above mentioned questions is **"Forensics Study"**

In ancient times, detectives or trackers performed investigations with their knowledge and got the clues when they found human remains, or dead body, or any robbery (Shafiq et al., 2023). The techniques and tools used by them were for appraising old objects,

photographs, archives, tracking people, ballistics, forensic anthropology, patient analysis, document analysis, timber dating, and geological analysis.

The identification feature in humans is called " Biometrics," which includes fingerprint verification (Nazir et al., 2023), retinal and iris scanning, hand geometry, facial recognition, and signature verification. One of the anthropologists says that "There is a brief but informative biography of an individual contained (Afzal et al., 2023) Within the skeleton, if you know how to read it..." Clyde Snow, forensic anthropologist, can be seen in Figure 17.

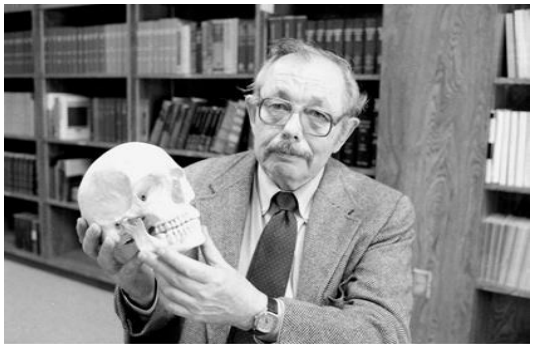


**Figure 17: Clyde Snow, Father of Forensics**

He also said, "There are 206 bones and 32 teeth in the human body, and each has a story to tell."
There are 206 bones in the human body, and bones help to estimate age, gender, ethnicity, height, trauma, and time at death (Gilanie et al., 2023). Each bone has a different size, growth rate, capacity, pattern, and thickness, which can be seen in Figure 18.

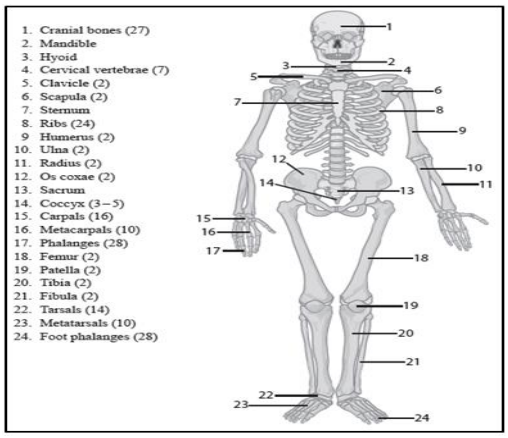



**Figure 18: Human Skeleton**

### 2.3 History of Forensics

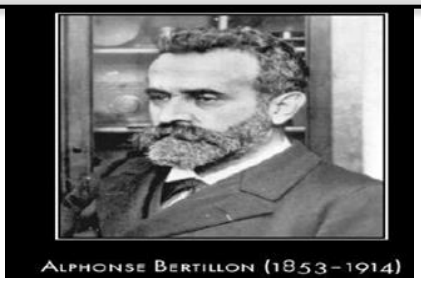
The word **"Forensic"** belongs to the Latin word **"forensic,"** meaning "FORUM".
In the time of the Romans, a criminal charge implied showing the case some time recently the public. Both the individual charged with the wrongdoing & the informer (Ahmed et al., 2023) would grant addresses based on their side of the story (Khera et al., 2023). The individual with the best argument would determine the outcome of the case, which is being shown in Figure 19. The medical impairment of age ranges as per law is described in Table 1.



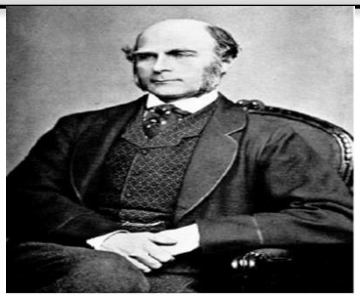
**Figure 20: First Meeting in the Palace Of ROME**

### 2.4 Famous Inventors of Forensics.

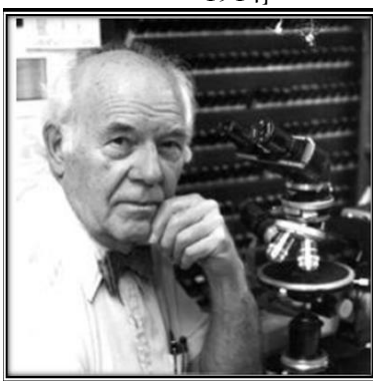
Here, I would like to introduce the most important people who invented the forensics methods, as shown in Figure 21.




(a) Alphonse Bertillon [1853-1914]



(b) First Fingerprint



Walter McCrone (1916-2002)

Dr Ascor Amoedo (1863-1945)

**Figure 21: Famous inventors of forensic**

**Table 1: Medical Impotence of age ranges as per the law**

| Age Encircled | Body part article | Status As per Law |
|---|---|---|
| Fetus (Intra-uterine life: 0-9 months) | The umbilical cord is a precursor to ossification nuclei and is important to brain development | Prohibition of gender prediction |
| Infancy (0-2 years) | Anatomical location of the primary centers of ossification in the hand, wrist bones | Ordinarily, in the custody of the mother |
| Childhood (3-7 years) | An indication of cranial growth is the appearance of the last ephemeral molars and the size of the carpals and metacarpals on the hand wrist. | Prohibition of employment in factories Ordinarily, in custody of the mother Not capable of committing an offense under 12 years |
| Juvenile (8-10 years) | Development of the craniofacial structure | Not capable of committing an offense under 12 years old, prohibited from employment in factories |
| Adolescence (11-18 years) | The eruption of the second permanent molar, the onset of puberty, the change in voice pattern the growth of cranium | Marriage age of 21 years for men, Guardianship orders, Age of employment, Prohibition to purchase tobacco, pornography, lottery tickets |
| Young adult (18-40 years) | Anatomy of third ring fusion, Diaphysis fusion, Hand-wrist | Obtaining a driving license and housing, obtaining voting rights Obtaining a driving |

| | | |
|---|---|---|
| | bone fusion, Clavicle sternal end fusion, Closure of cranial sutures | license and obtaining a motor vehicle |
| Adults (30-60 years) | Open Amalgamation<br>Auricular surface changes<br>Acetabular surface changes<br>Sternal conclusion of ribs<br>Closing of Sagittal sutures<br>Facial versatility, wrinkles, surface, color Voice design modification | Voting rights, Work age, driving permit, Get lodging and engine vehicles |
| Old age (60+ years) | Combination of the entire body<br>The manubrium of the sternum appears | Superannuation assistance<br>Annuity Claims |

Teeth are the least affected then other bones by external and physical factors be found for a long time in a dead body (Sehrawat and Singh, 2020). Even teeth can survive at a temperature of 1300 degrees (Shafiq et al., 2023). Mandible is the toughest bone that can survive for a longer period, almost 100 years, and can be useful to estimate age and sex in both living and dead, which can be seen in Figure 22.

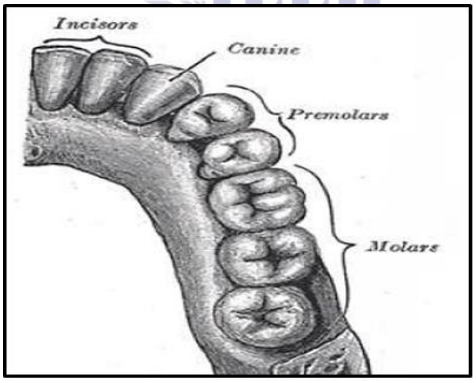



**Figure 22: Types of Teeth Age Wise**

Tooth is considered a more reliable source of age estimation because of its resistance to organic deterioration. The best thing about "TEETH" is that the teeth bone can be used to determine both age and gender; no other bone can give a clue about both biomarkers.

**Famous Cases in History**

In dentistry history there are many famous cases reported where the identification of an individual was done with the help of teeth.

**Joseph Warren (June 11, 1741 – June 17, 1775)**

The primary scientific dental practitioner within the United States was Paul Love, who was known for the recognizable proof of fallen soldiers (Janjua et al., 2017). Dr. Joseph Warren, who endured an extreme

head injury amid the war, was distinguished by the little denture that Paul Love had created for him, as shown in Figure 23. Through this recognizable proof, it was made conceivable for Dr. Warren to be buried with full military honors just after the end of World –II.

**Figure 23:** Joseph Warren (June 11, 1741 – June 17, 1775)

**Dr. George Parkman**

He was a regarded teacher at Harvard College who moreover managed with genuine bequest and lending money. John Webster, a colleague of mine at Harvard, who was a chemist, owed Dr. Parkman an impressive sum of money, as shown in Figure 24. One evening, Dr. Parkman failed to return domestic from supper on November 23, 1849.

**Figure 24: George Parkman (February 19, 1790 – November 23, 1849)**

John Webster's research facility was looked at, and a tea chest containing human remains was found, can be seen in Figure 25.

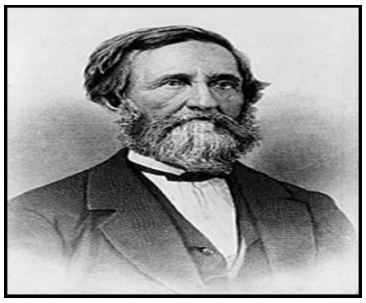


**Figure 25: Nathan Cooley Keep (1800–1875)**

Within the heater, parts of the maxillary jaw were discovered. At the trial for John Webster, Dr. Nathan Cooley Keep, Dr. Parkman's dental specialist, distinguished the teeth as part of the

maxillary and mandibular dentures he had made three a long time prior for the victim, as shown in Figure 26. This was the primary time dental prove was used to convict a killer.

**Figure 26: John White Webster (May 20, 1793 – August 30, 1850)**

This case is additionally an incredible illustration of how a master declaration was utilized in court, as shown in Figure 27.


**Figure 27: Proof of Murder and Copy of Trail Case**

**Adolf Hitler 20 April 1889 – 30 April 1945**

After the conclusion of World War II, there were rumors Adolf Hitler had gotten away with his spouse Eva Braun. Really they had passed on together in 1944, as shwon in Figure 28. In any case their bodies had been burned and after that buried by Russian soldiers.

**Figure 28: Adolf Hitler, 20 April 1889 – 30 April 1945**

Due to the need for ante-mortem and autopsy records, it was a challenge to dispel the rumors that they were still alive, as shown in Figure 29. At last, pieces of Hitler's mandible were found that uncovered leftovers of a bridge as well as unusual shapes of recreation to the mandible with proof of periodontal disease.

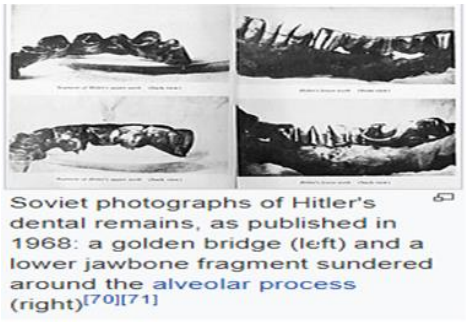



**Figure 29: Adolf Hitler's Teeth after Death**

Adolf Hitler's character was affirmed when the work coordinated the records kept by his dentist, Hugo Blaschke.

**Figure 30:** Hugo Johannes Blaschke (14 November 1881 – 6 December 1959)

**John Fitzgerald Kennedy (May 29, 1917 – November 22, 1963**

Several years after the assassination of John F. Kennedy, an English author named Michael Eddowes began raising suspicion concerning the identification of Lee Harvey Oswald, as shown in Figure 31. He believed the body buried in 1963 in Oswald's grave was a Russian spy. Therefore, to set the record straight, the body was exhumed and identification of Oswald was made on October 4, 1981, with military ante-mortem dental records (Sheiham et al., 1982).

**Figure 31: John Fitzgerald Kennedy (May 29, 1917 – November 22, 1963)**

## 2 Literature Review

This study aims to distribute wise age groups estimation using a robust AI-based diagnostic system using CNN. A local data set of 1586 patients are collected from Kyung Hee University Dental Hospital. ResNet-152 model was trained with 152 layers. Cross-entropy loss function and adaptive moment estimation (Adam) are optimized. Accuracy is 94% to 98% for all age groups estimation (Kim et al., 2021). Another research focused on the identification of age and gender, both features of humans from panoramic dental x-ray to facilitate forensics, estimation results can be used as an evidence civil and criminal laws. The methods used for calculating the center of gravity, area, perimeter, similarity, and ratio of teeth after applying basic image processing. Every method labeled with M1, M2, and M3 and applying contrast stretching, foreground enhancement, edge detection respectively. More than 1315 panoramic dental x-ray images were used with 162 different groups as datasets and all teeth images got specified labels, which include gender, age, tooth number and count. The Average results of M1, M2, and M3 are 85%, 89%, 84% respectively. The accuracy is not recommendable of this research (Ghaffar et al., 2022) because it not touching the ceiling point at 90%. No solution is given if the database is damaged or lost. There is a major issue will database used locally or remotely or even available on cloud (Avuçlu and Başçiftçi, 2020). This study tries to figure out the usefulness of mandible ramus length using Cone Beam Computerized Tomography (CBCT) to estimate age and sex. Data set of 213 people (99 males and 114 females) belongs to age group of 7 to 58 years. Length of candylon superior and gonion is measured to estimate the sex using CBCT and two fitted regression models developed to estimate age separately for male and female. No considerable changes found till the 17-year-old age group. Accuracy of sex estimation found 67% can be raised up to 82% depending on size of ramus while it shows accuracy of 65 % in age estimation up to 30 years of age that can raised up to 90%. In this study a very limited data set of a specific region is used and not available for the public. Moreover Accuracy level not up to the standards (Motawei et al., 2020). In this study ages estimation processed using measurement of pulp-tooth volume ratio (PTVR) from x-ray images. It's also called method of secondary dentine deposition (Gilanie, 2019). Data set of 392 people (207 male, 185 female) were used, and their ages were between 16 to 76 years. Sample data of 40 individuals is also used for validation purposes to drive regression equations. Acquisition, segmentation, masking and region growing applied on images CBCT using specialized software to calculate exact PTVR (Gilanie et al., 2021e). The result showed that PTVR can estimate chronical age much better result in females but not accurate in male. The accuracy was 85.16%. for both genders. The limitation of this study is a very limited data set. (Fei Fana,1, Wenchi Keb,1, Wei Wua, Xuemei Tianc, Tu Lyuc, Yuanyuan Liud, Peixi Liaoe, Xinhua Daia, Hu Chenb, *, Zhenhua Denga, *(2020). In this study the accuracy of three different methods (Demirjian, Willems and Nolla) are being tested to find out the chronical age (CA) (Naveed et al., 2024) of person. A dataset of around 2000 panoramic dental x-rays was obtained from the local hospital (medical university of xian jaintong.). The data set was composed of 50 % male and 50% female whose ages were 5 to 14 years. To evaluate age estimation person's gender, birthday, and date of orthophantomogram were considered and CA calculated by subtracting date of birth from date of x-ray consisting serene permanent teeth except third molar. The result were satisfied for Demirjain and Nolla's methods showed 86% and 90% accuracy between age group of 6 to 10 years according to KAPPA index (Asghar et al., 2023). Where Willems method produces 94 % accuracy in all age groups. It is concluded that Nolla's and Willems methods are more feasible to calculate the CA. Limitation of this study is the local dataset and the limited range of age groups. (Han, Meng-qi; Jia, Si-xuan; Wang, Chen-Xu; Chu, Guang; Chen, Teng; Zhou, Hong; Guo, Yu-cheng (2020). The objective of this study is to estimate bone age assessment from poor quality x-ray images by enhancing their quality using Convolutional Neural Networks (Gilanie et al., 2018b). In this study a publicly available dataset of 1400 x-ray images of the left hand are used. The dataset is composed of different races like Asian, Black, Caucasians and Hispanic people from the age group of 0 to 19 years. The regression model of

BotNet + CQ & Bot Net DQ were used to add Poisson noise and black labels on images, and resolution was also reduced by 4 times. To enhance performance of the model 5-fold cross validation was implemented on all datasets and produced 98% accuracy of classification and proved that BotNet + DQ is much better model than BotNet CQ model. The limitations of this study are datasets are generated through simulators and this model cannot work on real world dataset. The focus of study is also divergent from bone age assessment to image enhancement. (Guo, Jiajia; Zhu, Jianyue; Du, Hongwei; Qiu, Bensheng (2020)). This study proposes the best regression model of magnetic resonance for age estimation from images of ankle joint. The dataset of 590 persons, among them 372 males and 218 females who's ages were 8 to 25 years was obtained from local hospital of west china since April 208 to july 2019. The method of Two, Three staging and six stage staging were applied, analysed and compared on one-side sagittal images. The results were promising for Two stage staging and six stage staging than Three stage staging using (Mean Absolute Deviation )MAD (Batool and Gilanie, 2023) for distal tibia and ankle bone with accuracy of classification rate 87.5% calcaneus in male adults and 50% in teenage with MAD of 2.15 years while in female it produced MAD of 1.67 years with accuracy of 100% in adults and 44% in teenage group. The limitation of this study is short number of dataset and only applied on local dataset. (Lu, Ting; Shi, Lei; Zhan, Meng-jun; Fan, Fei; Peng, Zhao; Zhang, Kui; Deng, Zhen-hua (2020)).The main objective of this study is to estimate the age by visualizing secondary dentin inner layer cover by pulp when teeth is found broken in x-ray images. The dataset is obtained from a two different local medical institutes and grouped with labels of "HTT" and "TAU" respectively. Both dataset are separated on the basis of age, gender and ethnicity. HTT dataset was composed of 43 males and 17 females who belongs to age group of 19 to 60 years with removal lower polar having low socio economic status. The TAU is based on 7 males and 10 females of high socio economic status between age group of 11 to 60 years and their Ninth lower polar was missing. The method of scanco medical uCT 50 was used to scan images then a software called "Amira " used to analyze SD and segmentation , erosion and SD borders were applied. For histological - procedure on TAU dataset is used. The CEJ(Cemento-enamal junction) was used for regression to obtain virtual segmentation . Regression analyses produce 82% accuracy as compared with old method of " gold-standard" with accuracy of 54% for age estimation . The data set is too much short and obtained locally. The Accuracy of this model is also not upto the mark.( Nudel, Itay; Pokhojaev, Ariel; Hausman, Bryan S.; Bitterman, Yoli; Shpack, Nir; May, Hila; Sarig, Rachel (2020). )This study is aim to distribute toot wise age groups estimation using robust AI based diagnostic system using CNN (Gilanie et al., 2019a). Local data set of 1586 patients is collected from Kyung Hee University Dental Hospital.ResNet-152 model was trained with 152 layers. Cross-entropy loss function and adaptive moment estimation (Adam) optimize. Accuracy is 94% to 98% for all age groups estimation. (Seunghyeon Kim, Yeon-Hee Lee, 2021). This study aims to estimate gender from mandibular stricture using x_ray with the help of artificial neural network. The total data set of 509 radiographs were used among them 256 male and 253 were female belongs to different age group of 18 to 70 years. There are two main methods morphometric measurement and inter observer variability applied in model of artificial neural network. The accuracy for male was 69.9 % and its was 61.1% for female. The dataset used in this model is too much short in numbers. The accuracy is also not up to the marks.( Patil, V., Vineetha, R., Vatsa, S., Shetty, D. K., Raju, A., Naik, N., & Malarout, N. (2020). This study conducted to estimate chronological age with mandibular x_ray image by using statistical methods to evaluate Kavaal's method. The dataset of 360 OPG (Orthopantomogram) among them 50% were male & female. They belongs to age group from 20 to 65 years. All dataset was measured vertically using adobe Photoshop cs 6.0 . The measurement of tooth pulp and roots were considered from A-C CEJ (Cemento-enamel junction). B level used for horizontal measurement. Intra class correction coefficient method used for classification and regression. The result accuracy score from 72% up to 92%. The limitation is the local dataset with lowest number. This study proposed a regression model using CNN to identify for emergency patients from

their x_ray to estimate age . A predefined dataset of 22431 x_ray images was used with fully labelled extractions. The method (Gilanie et al., 2022a) adopted to train the were Fast CNN artificial intelligence, Dense Net 121 along with Res Net 50 and mean absolute error(MEA ) . The accuracy in this model was 90% which is good one. While augmented dataset should not be used in this study.( Carl F. Sabottke1,2 & Marc A. Breaux1,2 & Bradley M. Spieler2Received: 29 February 2020 /Accepted: 16 April (2020).This is aims to estimate the age from hand x_ray using U-Net along with active learning using DCNN(Deep Convolutional Neural Network) (Asghar et al., 2023)The dataset of only 300 images was selected from 12611 images from RSNA( radiological society of north America). Main two methods were used for bone age assessment one called GP( Greulich and Pyle) and TW( Taner Whithouse ) to design the model using fully connected layers. For bone age assessment SVR (Support Vector Regression) (Gilanie et al., 2021a) and KKR(Kernel Ridge Regression)and leaner kernel . The accuracy of the result found 95%. The dataset selected to train the model was very limited and local. In this study the sex is estimated from CT( Computerized Tomography ) of first cervical vertebra. The dataset 200 males and 100 females who were having less than 18 years of age. From transversarium 6 parameter were extracted to distance between first cervical vertebra atlases. The accuracy for identification of gender was 78.8%. The limitation is the limited and local data set and results are also not promising.( Seda Sertel Meyvaci a,*, Yasin Arifoglu b, Safiye Gurel c, Ahmet Buber d(2020)) This is aimed to identify gender from hand x_ray in Nigerian people. The data set of 50 males and 50 females was used. Age group of both gender were 20 to 50 years. For classification of gender the middle distal phalanges proximal and metacarpals of the finger used to measure the mean difference between male and female using walk's lambda test. The accuracy found 69% from metacarpals and 66% from proximal phalanges. The dataset used is too much short in numbers while the result accuracy is also not up to the mark (Ade S. Alabi a,*, Eric O. Aigbogun Jr. b,*, Ann M. Lemuel b,*, Mariam B. Buhari a,*(2020)). This study aims to classify gender type from x_ray of skull cranium and mandible using matric and geometric methods and multi slice computed tomography. The dataset of 120 people was used among them 63 were male and 57 were female while there age groups were between 25 to 82 years and 23 to 84 years respectively. Univariate analysis and logistic regression was used along with GPA(Generalized Procrustes analysis), Godall's F and Mahalanobis D's used for segmentation and classification (Hafeez et al., 2023). The accuracy found 88% for skull cranium and 81% for mandible. The data set is too much short in numbers and the results of study are no touching the standard mark of 90% or above.( Claudia Gillet1 & Leonor Costa-Mendes1,2 & Camille Rérolle1,3 & Norbert Telmon1,4 & Delphine Maret1,2 & Frédéric Savall1,4(2020)). This study aims to estimate the gender fro x_ray of pelvic bone using CNN( Convolutional Neural Network). The dataset of 900 DICOM images among them 600 were female and 300 were male. Their age group was 16 to 100 years and 16 to 95 years respectively. First all images were converted from 2D to 3D using homologous technique (Sharma et al., 2022). The methodology for to train the model were Google Net. And Res.Net 50. The accuracy was 91% which is good one. The only limitation of this study is very limited data set.( Mamiko Fukuta a,*, Chiaki Kato a, Hitoshi Biwasaka b, Akihito Usui c, Tetsuya Horita a, Sanae Kanno a, Hideaki Kato a, Yasuhiro Aoki a(2020)). This study proposed to estimate biological using hand x_ray images with deep lingering network using spatial transformation. The dataset of 1229 images was used having age group of 0 to 17 years. The bifurcation of data set with respect to gender is 421 male and 809 female. The model was being trained using mean absolute error along with CNN(Convolutional Neural Network) along with Res.Net 18 to obtain extra features. The accuracy of the result is very good having 97% score. The limitation in the study is local and very limited data set. The range of age only 17 years for prediction which is limited for 18 and above ages groups.( Yaxin Han a , Guangbin Wang b , ∗(2020)). This study is estimating age using CNN(Convolutional Neural Network) from OPG(Orthophentogram) dental x_ray of lower left third molar. The dataset of 400 OPGs was obtained from local hospital. 20% images were gender oriented while 80 OPGs were used for

validation and 320 for training. The model was trained using CNN by localization, segmentation using ROI( Region Of Interest) of lower left third molar. The average result was 93% which is good one. The limitation of this study was very limited data set. The ROI was huge which should be smaller in dimension with respect to area for better performance.( Nikolay Banar1 · Jeroen Bertels2 · Franc¸ois Laurent2 · RizkyMerdietio Boedi3,4 · Jannick De Tobel4 ·Patrick Thevissen4 · Dirk Vandermeulen2,5(2020)). The study proposed a statistical model to estimate the age using CNN( Convolutional Neural Network) from x_ray images of pelvic bone. The dataset of 2137 x_ray images was collected, among them 1215 were male and 922 were female. The age group was 10 to 26 years of age for both genders. Kerienter, Kelling Ghaus methods were used for measurement. Ossification, fustian of iliac crest and ischial tuberosity were compared for Mean Error. While SVR( Support Vector Regression) and GBR(Gradient Boosting Regression) were used for age estimation. The accuracy of the model was 92% which is good one. The limited dataset and the age group range for model training is very limited.( Fei Fana, Xiaoai Donga, Xuemei Wub, Rui Lic, Xinhua Daia, Kui Zhanga, Feijun Huanga,*, Zhenhua Denga,*(2020)). This study proposed to estimate dental age from x_ray image using Kavaal's method to distribution into different age groups. The dataset of 703 x_ray images among them were 459 mandibular and 244 were maxillary. Linear and their mean values obtained from T(Root to Tooth length ) P ( Pulp to Tooth) and R(Pulp to Root). The CEJ ( cementoenamel junction) also include measurement of Kavaal Method. The result were very good up to 98%. The dataset was very limited in size and accuracy is specific for 18 to 60 years only.( JS Sehrawata,*, Monika Singhb(2020)). This study aims to determine gender from mandibular ramus measurement using CBCT (cone beam computed tomography) . The dataset of 70 x-ray images Amon them were 35 were male and 35 were female who belongs to age group 24 to 26 years. The methodology of measuring the distances mandibular ramus using SPSS(Statistical Package for the Social Sciences) and mouse driven method by M1(Coronoid height) M2 ( Cardinal height) M3 ( Mandibular ramus height), M4 ( Max ramus breadth) and M5 (Min ramus breadth) and their linear values. The accuracy of result for male score 77% while it was 73% for female. The limitation of his study is very limited dataset obtained from a local hospital. (Alime Okkesima, Turkan Sezen Erhamzab,*(2020). This study proposed a model to estimate sex from mandibular x-ray image using statistical techniques. The dataset of 50 OPGs( Orthophentograms) used. There were 50% male and 50% female who belongs to age group of 21 to 45 years of age. The methodology adopted in this study is inter and intra observe reliability coefficient about measurements applied with inter class correlation and binary logistic regression by SPSS. The accuracy produce 75% in female while it was 80% for male. Overall accuracy was 76%. The limitation in this study is very limited number of dataset and no AI technique used for feature extraction. Doha Abualhija*, Gavin Revie, Scheila Manica(2020). This study proposed to estimate the bone age from left hand x-ray images. The dataset of 442 x-ray images were used and 220 of them were female and 222 male were who belongs to different ethnic groups like Asian, African, American, Caucasian and Hispanic .The age group specified from 0 to 18 years only. The methodology to train the model used processing of diffusim and filtent, ROI(Region of Interest), extracted with HOG(Histogram Oriented Gradient), LBP(Local Binary Pattern) and dense shift classified into specific categories using SVM( Support Vector Machine). The Five Fold cross validation is also performed for analysis. The accuracy is male found 68% and 73% in female. This study used local and very limited dataset. The accuracy is also not up to the mark. Farzaneh Dehghani1 & Alireza Karimian1 & Mehri Sirous2(2019).This study aims to classify gender type from x_ray of skull cranium and and mandible using matric and geometric methods and multi slice computed tomography. The dataset of 120 people was used amng them 63 were male and 57 were female while there age groups were between 25 to 82 years and 23 to 84 years respectively. Univariate analysis and logistic regression was used along with GPA(Generalized Procrustes analysis), Godall's F and Mahalanobis D2 used for segmentation and classification. The accuracy found 88% for skull cranium and 81% for mandible. The data set is too much short in numbers

and the results of study are no touching the standard mark of 90% or above.( Claudia Gillet1 & Leonor Costa-Mendes1,2 & Camille Rérolle1,3 & Norbert Telmon1,4 & Delphine Maret1,2 & Frédéric Savall1,4(2019)). This study proposed a method to estimate age of Malaysian children using deep convolutional neural network. The ladled dataset of 456 OPG( orthophentograms ) of patients 50% male and 50% female who were having ages between 1 to 17 years . The labelling was done with the help of connected component using ROI ( region of interest ). Feature extraction performed with principal component analysis and 2d CNN( convolutional Neural Network) used for classification. The accuracy of the result went up to 82.62% in male while it was 83.60% in female. In this study local and very limited dataset is used. Accuracy is also not up to the mark. (Seyed M. M. Kahaki1 • Md. Jan Nordin2 • Nazatul S. Ahmad3 • Mahir Arzoky4 • Waidah Ismail5(2019)). The study aims to estimate the individual's age with dental and chronological ages. In this study data set of 627 children (407 boys, 220 girls) of 5 to 12 year age group .The accuracy of Demerjain's four methods is tested with comparison of his own old method of age estimation. Lower left quadrant permanent teeth used in all four methods as scaled up to A to H rating with sum of maturity score out of 100 converted into dental age (Khera et al., 2023).A specialized model of DCCN(Deep Convolutional Neural Network) designed for this study. The results showed that Demrjain's four method is more accurate for male and considerable change found in chronical age and dental in group of 5 to 8 and 11 years in male and 5 to 7 and 9 years old in female. Most considerable change was found in 5 years age group in both genders. Data set is too much limited and only used for small age group. The accuracy was 92% given. Its gender specific method of age estimation only accurate for males.( Seyed M. M. Kahaki1• Md. Jan Nordin2• Nazatul S. Ahmad3• Mahir Arzoky4• Waidah Ismail5(2019). Another study is addressing about the identification of gender is more complex and time consuming when only skeleton remain. Pelvic girdle is consider more reliable for gender estimation among all other bones (Siddique et al., 2025). Determination and comparison measurement of ilium bone x-ray. Two basic models are followed in this research cross section and descriptive analysis. A special system PACS (Picture analysis and communication system) is used to measure height of ilium, inter-acetabular distance, acetabular diameter and pelvic breadth. Dataset of 90 male and 90 female volunteers is used who were suffering from some skeleton disease or pelvic trauma. The final results were varying in accuracy with respect to sensitivity, age group, and genders. The accuracy ranges from 77% for ilium height for gender estimation and 70% for acetabular diameter and breadth. The main gap of this study is the accuracy, which is below 80%. Limited dataset used to this research it should be in thousand (Varzandeh et al., 2019). Problem of age determination is another biggest issue for immigrants and finding age clues in criminal activities for forensics as well as law enforcing agencies is being address in this study. Here cameriere adopted to estimate the age by making relation between age and third molar maturity index. this method is helpful for estimation of both ages groups below 18 years and above 18 years by cut-Off value 0.08 (I3m= 0.8).By measuring length and width of third molar index used with statistical approach the age is estimated .Dataset of only 276 students is used. Among them 139 female and 137 were male and their age is between 14 to 24 years. Dataset of such students is discarded who are obsessive or born premature. Result are based on sensitivity for boys is 89% for girls is 84% . Specificity results for boys is 96% and for girls is 93% .Result of positive productive value for boys is 92% and for girls is 87%. This study has issue of very small dataset. Basic image processing techniques like enhancement, feature extraction and segmentation are missing for x-ray image (Kumagai et al., 2019). Another study (Anwaar et al., 2024) defining that the exact estimation of gender is most difficult task and it requires some specialist to perform this task. The aim is to present fastest, accurate approach for gender estimation from panoramic dental x-ray images. The classification method is (ULLAH et al., 2024a) performed on cranial bone images using DCN layered approach. Softmax activation function is used to obtain probabilities in type and frequency of layers. The system trained to classify images on the basis of their morphological features and compare them. More than 4000 high quality images having dimensions of

3256 x 1536, 8 bits per pixel are used as dataset. The dataset contain dental x-rays of people belongs to different age group and genders (male 40% and female 60%). The result shows are obtained in four staged experiments and produced accuracy above 82% in first and last experiments. On other hand the result accuracy is above 90% in age grouping section between 20 to 80 years, but accuracy decrease dramatically and shows 50% when age is above 80 years. Average accuracy of this study is 94.3% which is good. This study can be used to estimate the age as well as race of person (Ilić et al., 2019). This research is to
evaluate the performance of Demirjian's method by comparing dental age estimation from it with chronological age. This study helps to resolve the issue of such people who have no documentary proof of age. New weighted scoring using center of linear regression Dataset of 1260 of students among them 566 male and 694 female adopt the method SD (standard deviation) method of polynomial percentile while their age rages from 5 to 17 years old. Dataset divided into two categories set-1 for DA(dental age) using Demirjian's method having 420 male and 531 female and their samples are labeled with 8 staged categories from A-H . Set-2 having 146 male and 163 female students for estimating CA (chronological age). The results are good the difference found in DA and CA is less than 1%. This study is limited to a specific age group no solution for above age groups. Another gap in this study is less no of dataset (Khdairi et al., 2019).

**Table 2: State of art of previous studies**

| Sr. No. | Studies | The proposed Methodology | Dataset used | Evaluation measures achieved |
|---|---|---|---|---|
| 1 | (Seunghyeon Kim, Yeon-Hee Lee, 2021) | Robust artificial intelligence (AI)-based diagnostic system for age-group estimation by incorporating a convolutional neural network (CNN) | 1586 Images | 94% to 98% Accuracy for all age groups |
| 2 | (Avuçlu & Başçiftçi, 2020). | Contrast-stretching Connected-Zoom and free drawing operations Components Labeling | 1315 images | Average results of M1, M2, and M3 are 85%, 89%, 84% respectively |
| 3 | Motawei, Shimaa et all M(2020). | CBCT and two fitted regression models | 213 people 99 males & 114 females | Accuracy 67% |
| 4 | Fei Fana,1, Wenchi Keb,1, et all(2020) | Regression equation. Acquisition, segmentation(PVTR) | 392 people 207 male, 185 female | Accuracy 85% |
| 5 | Han, Meng-qi; Jia, Si-xuan; Wang, Chen-Xu; Chu, Guang; Chen, Teng; Zhou, Hong; Guo, Yu-cheng (2020) | Demirjain and Nolla's methods & KAPPA index | 2000 Images 50% Male and 50% Female | Accuracy 94% |

| | | | | |
|---|---|---|---|---|
| 6 | Guo, Jiajia; Zhu, Jianyue; Du, Hongwei; Qiu, Bensheng (2020) | regression model of BotNet + CQ & Bot Net DQ | 1400 Images | Accuracy of Classification 98% |
| 7 | Lu, Ting; Shi, Lei; Zhan, Meng-jun; Fan, Fei; Peng, Zhao; Zhang, Kui; Deng, Zhen-hua (2020) | Two stage staging six stage staging Three stage staging & MAD(Mean Absolute Deviation ) | 590 persons 372 males and 218 females ages group 8 to 25 years | Accuracy 87.5% |
| 8 | Nudel, Itay; Pokhojaev, Ariel; Hausman, Bryan S.; Bitterman, Yoli; Shpack, Nir; May, Hila; Sarig, Rachel (2020). | segmentation , erosion & CEJ(Cemento-Enamal Junction) | 43 males & 17 females Age group 19 to 60 years | Accuracy 82% |
| 9 | (Seunghyeon Kim, Yeon-Hee Lee, 2021) | ResNet-152 model was trained with 152 layers | 1586 Dental Images | Accuracy 80% |
| 10 | Patil, V., Vineetha, R., Vatsa, S., Shetty, D.K., Raju,A., Naik,N., & Malarout, N. (2020). | Morphometric measurement & inter observer variability applied in model ANN( artificial neural network) | 509 images 256 male and 253 Age group 18 to 70 years | Accuracy 69.1% |
| 11 | Fan, Fei; Ke, Wenchi; Wu, Wei; Tian, Xuemei; Lyu, Tu; Liu, Yuanyuan; Liao, Peixi; Dai, Xinhua; Chen, Hu; Deng, Zhenhua (2020). | Kavaal's method ECJ (enamelocemental-juncti) | 360 Images 180 male & 180 Female Age Group 1 to 17 years | Accuracy 72% |
| 12 | Carl F. Sabottke1,2 & Marc A. Breaux1,2 & Bradley M. Spieler2(2020) | CNN, Dense Net 121, Res Net 50 | 224,316 chest radiographs | Accuracy 94% |
| 13 | Xiaoying Pan,1 Yizhe Zhao,1 Hao Chen ,1 De Wei,1 Chen Zhao ,2 and Zhi Wei3(2020) | GP( Greulich and Pyle) and TW( Taner Whithouse ) SVR, KKR | 300 images | Accuracy 95% |
| 14 | Seda Sertel Meyvaci a,*, Yasin Arifoglu b, Safiye Gurel c, Ahmet Buber d(2020) | SD,FTM,FTL 1 TO 6 | 200 males & 100 females | 78.8% |

| | | | | |
|---|---|---|---|---|
| 15 | Ade S. Alabi a,*, Eric O. Aigbogun Jr. b,*, Ann M. Lemuel b,*, Mariam B. Buhari a,*(2020) | Statistical walk's lambda test 1D to 5D | 50 males & 50 females Age group 20 to 50 Years | 66% |
| 16 | Claudia Gillet1 & Leonor Costa-Mendes1,2 & Camille Rérolle1,3 & Norbert Telmon1,4 & Delphine Maret1,2 & Frédéric Savall1,4(2020) | Univariate analysis & logistic regression GPA(Generalized Procrustes analysis), Godall's F & Mahalanobis D's | 120 people 63 male & 75 Female Age group Male= 25 to 82 years Female= 23 to 84 years | Accuracy 72% |
| 17 | Mamiko Fukuta a,*, Chiaki Kato a, Hitoshi Biwasaka b, Akihito Usui c, Tetsuya Horita a, Sanae Kanno a, Hideaki Kato a, Yasuhiro Aoki a(2020) | Google Net. & Res.Net 50 | 900 DICOM images 300 Male & 600 Female Male= 16 to 95 years Female= 16 to 100 years | Accuracy 91% |
| 18 | Yaxin Han a , Guangbin Wang b , *(2020) | CNN(Convolutional Neural Network) & Res.Net 18 | 1229 images 421 Male &809 Female Age Group 0 to 17 years | 97% Accuracy |
| 19 | Nikolay Banar1 · Jeroen Bertels2 · Franc¸ois Laurent2 · RizkyMerdietio Boedi3,4 · Jannick De Tobel4 · Patrick Thevissen4 · Dirk Vandermeulen2,5(2020) | CNN(Convolutional Neural Network) & ROI ( Region Of Interest) | 400 OPGs | Accuracy 54% |
| 20 | .( Fei Fana, Xiaoai Donga, Xuemei Wub, Rui Lic, Xinhua Daia, Kui Zhanga, Feijun Huanga,*, Zhenhua Denga,*(2020)) | CNN(Convolutional Neural Network) & SVR(Support Vector Regression) | 2137 images 1215 male & 922 female. Age group 10 to 16 years | Accuracy 92% |
| 21 | JS Sehrawata,*, Monika Singhb(2020) | CEJ ( cementoenamel junction) & Kavaal's method | 703 x_ray images 459 mandibular 244 maxillary | Accuracy 98% |
| 22 | Alime Okkesima, Turkan Sezen Erhamzab,*(2020) | SPSS(Statistical Package for the Social Sciences) M1,M2,M3 & M4 | 70 Images 35 male &35 Female Age Group 24 to 26 years | Accuracy 77% |

| | | | | |
|---|---|---|---|---|
| 23 | Doha Abualhija*, Gavin Revie, Scheila Manica(2020) | ICC(inter class correlation),BLR( binary logistic regression) | 50 Images<br>25 male &25 Female<br>Age Group<br>21 to 45 years | Accuracy 76% |
| 24 | Farzaneh Dehghani1 & Alireza Karimian1 & Mehri Sirous2(2019) | ROI(Region of Interest),HOG(Histogram Oriented Gradient), LBP(Local Binary Pattern) & SVM(Support Vector Machine) | 442 images 222 male & 200 female | Accuracy<br>Male =68%<br>Female=73% |
| 25 | Seyed M. M. Kahaki1 • Md. Jan Nordin2 • Nazatul S. Ahmad3 • Mahir Arzoky4 • Waidah Ismail5(2019) | DCCN ,2D CNN & ROI | 456 Images<br>207 Male 249 Female<br>Age group 1 to 17 Years | 83% |
| 26 | Seyed M. M. Kahaki1 • Md. Jan Nordin2 • Nazatul S. Ahmad3 • Mahir Arzoky4 • (2019) | DCCN , Demirjin's Method | 627 children (407 boys, 220 girls) of 5 to 12 year | Accuracy 92% |
| 27 | (Varzandeh et al., 2019) | PACS (Picture analysis and communication system) | Local Dataset having 90 male and 90 female | 77% for ilium height for gender estimation 70% for acetabular diameter and breadth. |
| 28 | (Ilić, Vodanović, & Subašić, 2019) | DCN layered approach. USING Softmax. | Local Dataset of 4000 high quality images dimensions of 3256 x 1536, 8 bits per pixel<br>male 40%<br>female 60% | AVERAGE ACCURACY 94.3% |
| 29 | (Kumagai et al., 2019) | intra-class correlation coefficient (ICC)<br>Cohen Kappa | Local Dataset of only 276 persons.<br>139 female<br>137 male<br>ages between 14 to 24 years | Accuracy in girls 87%<br>Accuracy in boys 91% |
| 30 | (Zhang, H(Khdairi, Halilah, Khandakji, Jost-Brinkmann, & Bartzela, 2019)uang, Du, & Wang, | SD (standard deviation)<br>Demirjian's method | Local Dataset of 1260 of students among them 566 male and 694 female | AVERAGE ACCURACY 96.% |

| | | | | |
|---|---|---|---|---|
| | 2017) | | | |

## 3 Proposed Methodology

On the platform of artificial intelligence, Deep Convolutional Networks (DCN) proved themselves to be helpful for estimation of scanned image of teeth. First simple dental X-Ray images will be scanned and machine will be trained on local data then texture, geometrical features of given data will be matched to evaluate the result. Dental X-Ray is most easiest and possible method to be adopted to determine faster and easier determination for age and gender on initial investigations for police, courts and other law enforcing agencies in Pakistan. There are many standard methods available to estimate age and gender. Most common methods for gender estimation are as under Morphological Methods.

### 3.1 Hard Tissue Analysis Tooth Size

Hard tissue examination Tooth estimate Odontoscopy, from dental human studies point of see looks for to watch records, analyze and get it the behavior of the expression of coronal and root morphology of human teeth. Thinks about have uncovered that estimations of the mesiodistal and buccolingual measurements of teeth are great markers of sex being the foremost most effortless and solid strategy to analyze sexual dimorphism (Anwaar et al.). The mesiodistal measurement is the most prominent remove between the contact focuses on the proximal surfaces of the crown and buccolingual measurement is characterized as the most noteworthy remove between the labial or buccal surface and lingual surface of the tooth crown. It is for the most part acknowledged that male postures bigger teeth than the inverse sex; subsequently, it is no astonish to numerous creators that the last mentioned has lower mesiodistal and buccolingual dimensions.[7][8]Nevertheless, there has been a wrangle about on which measurement (mesiodistal or buccolingual) grant way better comes about.

### 3.2 Canine Dimorphism

Canine teeth estimations (mesiodistal width, buccolingual width and inciso-cervical heigh) have been examined by a few strategies such as Fourier investigation and Moiretopography to say a few.Mandibular canines considered to be the "key tool" for individual recognizable proof are well known for showing the most prominent sexual dimorphism.[10] A few speculations have been given to clarify canine dimorphism. Agreeing toAcharya et al., Y chromosome deliver slower male development. Besides, the long period of amelogenesis handle in male contributes to this perception. As a result, male have thicker finish than female. Bossert and Marks in their think about detailed that assessment of changeless mandibular and maxillary canine teeth for sex assurance has certain preferences in that they are the slightest extricated teeth, less influenced by periodontal disease, last teeth to be extricated and contains a high (Kalistu and Doggalli, 2016), as shown in Figures 32 and 33 .

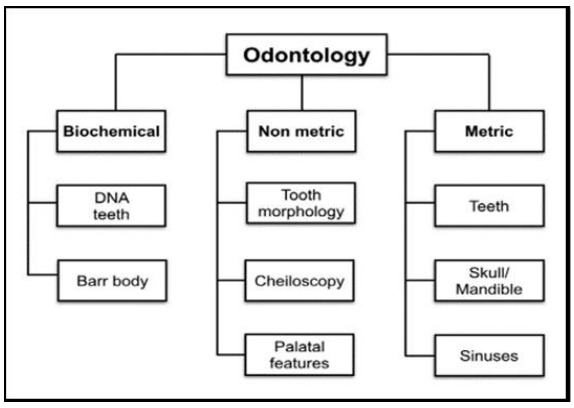



**Figure 32: Odontology Sub Branches**

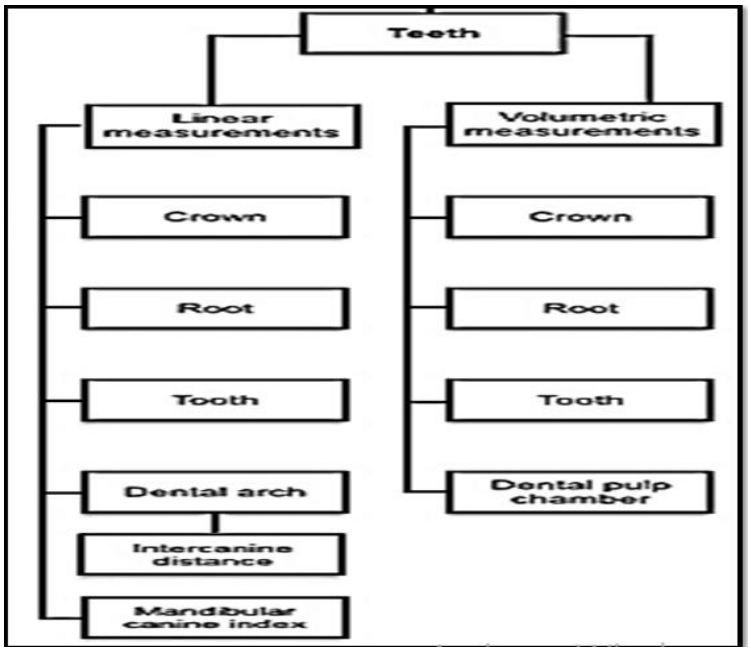



**Figure 33: Morphology of Teeth**

Sex contrasts in tooth dimension Teeth may be operated for separating sex by measuring their fee volume (m-d) and buccal and lingual aspects of tooth measurements. Typically of extraordinary significance in youthful people where skeletal ancillary carnal atmospheres have not however created. Considers appear critical contrasts amongst male and female changeless and evanescent tooth crown magnitudes, as shown in Figure 35. Amid teeth, submaxilla curs appear the most noteworthy.

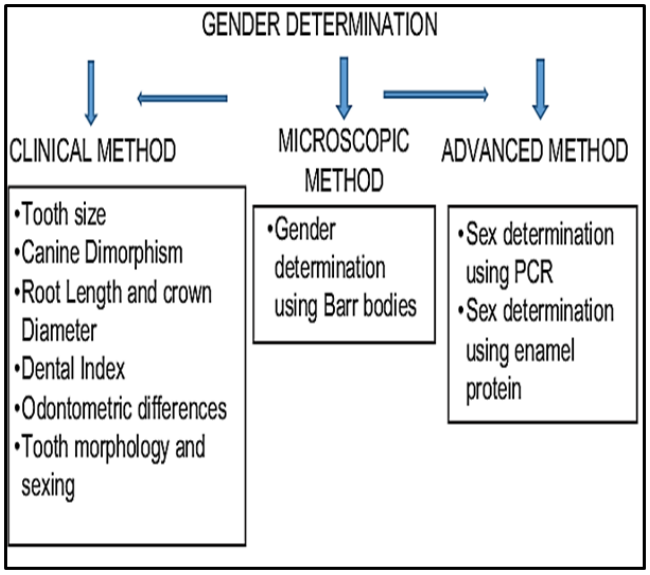



**Figure 34: Gender Estimation Methods**

Dimensional distinction with bigger teeth in guys than in females. Premolars, to begin with and moment fangs, as well as upper jaw grinder, are moreover known to have noteworthy differences.

Root distance and pinnacle span, as shown in Figure 35.

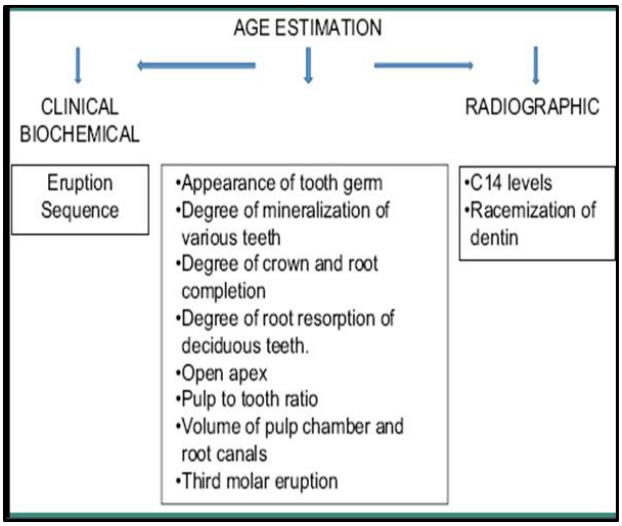



**Figure 35: Age Estimation Methods**

Using an optical scanner and radiogram metric estimations on mandibular lasting teeth, sex assurance can be accomplished with 80% exactness by determining root span and crown breadths. Sex assurance utilizing canine asexual in the field of legal orthodonture, changeless pooch teeth and their curve width (remove between the canine).

3.3 How Age can be determined from tooth?

3.3.1 Baby Teeth

Additionally called deplete or ephemeral teeth, start emanating at nearly six months, commencement with the central fangs inside the minor jaw (mandible). Each tooth sort - fangs, pooches, premolars, molars - radiates on an obvious plan. The fangs teeth are any of the four front teeth in each jaw, utilized for cutting and biting, as shown in Figure 36. The canine teeth are the four strident-jagged teeth another to the fangs.

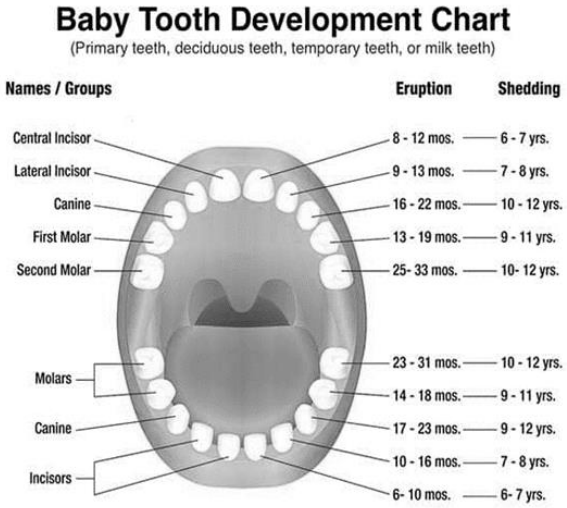



**Figure 36: Tooth growth with tooth labels**

Besides called deplete or ephemeral teeth, start emanating at nearly six months, beginning with the central fangs inside the lower jaw (mandible). Each tooth sort - fangs, canines, premolars, molars - transfers on an obvious plan. The fangs teeth are any of the four front teeth in each jaw, utilized for harsh and grinding. The canine teeth are the four sharp-piercing teeth another to the fangs.

### 3.4 Growth Criteria for Enduring Teeth

#### 3.4.1 Four to Five Years Old

In addition called deplete or ephemeral teeth, start transmitting at nearly six months, commencement with the central fangs inside the lower jaw (mandible). Each tooth sort - fangs, canines, premolars, molars - emanates on an obvious plan. The fangs teeth are any of the four front teeth in each jaw, utilized for harsh and grinding. The canine teeth are the four sharp-pointed teeth another to the fangs.

#### 3.4.2 Fifteen to Seventeen

A long time Prehistoric At this age, the roots of the third molars are immobile open, but other highpoints (crown wrap up, roots and teeth) are at their grown-up establish for to start with and minute molars, premolars.

#### 3.4.3 Over Eighteen Years Old

By this age, all geographies (crown enamel, roots and teeth) are in their grownup step for

### 3.5 Famous Methods developed for age and gender estimation:

- Gustafson
- Willem's
- Nolla
- Haavikko
- Chaillet and Demirjian
- Schour and Massler
- Atlas london
- Demirjin
- Kaaval's

I have proposed a model which is developed using above mentioned method Willem's because it produces suitable results.

Willems scheme measures the influential stages of the seven cleared out changeless mandibular teeth and is possible utilized for dental age estimation. Usually inside the intervening ± 0.5 a long time, a show with three teeth has 3% less actual age estimations than a show counting seven teeth.

I will use image processing along with artificial CNN (Convolution Neural Network) Artificial Intelligence for training of my model for classification of gender and Regression Model with SVM (Support Vector Machine) for age, as shown in Figures 37 and 38.



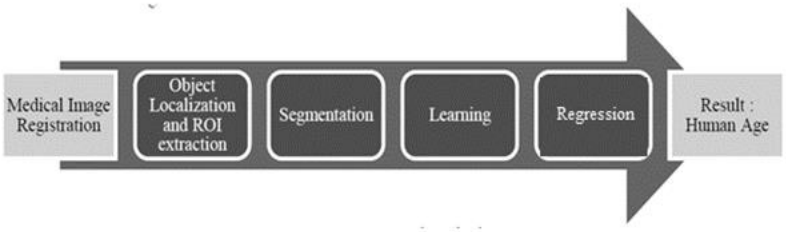



**Figure 37: Model for Age Estimation**

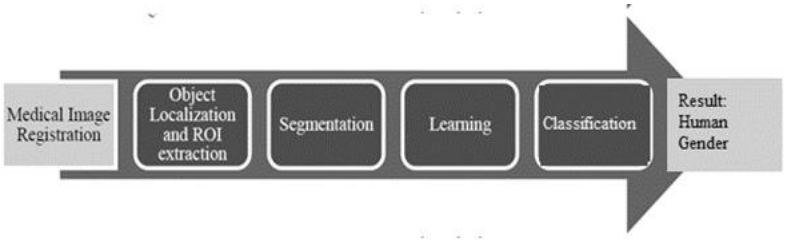



**Figure 38: Model for Gender Estimation**

### 3.6 CNN (Convolution Neural Network)

CNN may be a course of reflective learning neural systems. The core idea of CNN as machine learning calculation the receives picture as input, separate the different aspect inside the picture is said to be trained weights and leanings for understanding differences between two or more pictures. CNN mechanisms by acquiring features from the given image. The segmented layer that can be parallel or multi-type labels. The concealed layers containing convolutional layers. Re-LU (Rectified Leaner Function) layers, the assembling layers and full joined layers made complete neurotic network, as shown in Figure 39. It is extremely vigorous to get it that artificial neural network or genuine neural system which is composed of different neurons is not fully trained to acquiring special features from the given image. It is accomplished if convolutional and pooling layers are joined together. There is an issue that both layers cannot perform classification until a complete Neural Network.

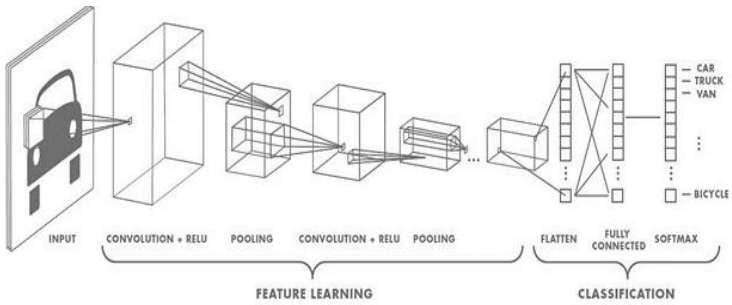



**Figure 39: CNN Model**

Let us think that if we need to differentiate between two pictures of birds and each one is labeled as Eagle, Sparrow, Parrot and Pigeon. As shown in Figure 40. Currently the need is to get these pre-labeled images and originates a machine erudition control that enables to leave a vacant bird's image and classified it separate category or its name. Occasionally we initialize to make a neural organize. We need to convert all the pictures into grayscale fames to proceed them further for classification. AS we know that all color pictures have three channels.

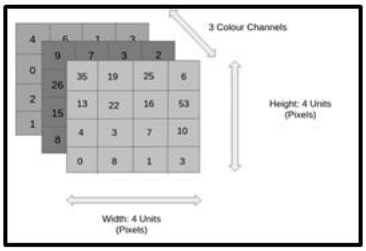



**Figure 40: RGB Color Straits of an Image**

RGB (red, green and blue) that is available in figure 3.4. The picture can be in different color schemes like RGB, grayscale, CMYK (cyan, magenta, yellow, and key (black)) and HSV (Hue Saturation Value).
The main issue is that a color picture have many channels having huge information in it that creates much more complexity for computations. In other words we can say that it's very difficult to deal when Neural Network or machine learning calculating with dissimilar information of RGB value to acquire details from images and arranged them into their proper categories. This section of CNN is used to reduce image in a simple form that can be easily processed without removing basic information.
Convolutional is very easy to deal with grayscale images they have single channel and it's quite easy to

acquire important features using convolutional layer. The convolutional layer can be made up to one or many Kernels having unique weights that help to acquire features from the given image.

In the above mentioned example kernel (K) composed of size 3*1*1( x 1 because working with grayscale image having single color ) having weights mentioned in Figure 41.

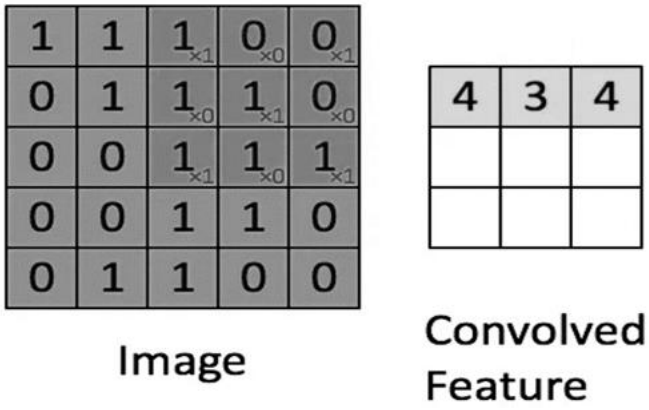



**Figure 41: Convolutional Window**

In figure 41 it's been shown that the kernel will convolute 9 time on a single image. It is called "Stride"

If we set the value of stride 1 it will complete 9 cycles to complete the whole image. The CCN sets the weights of Kernels by default (Yaseen et al., 2022). The process will acquire only the prominent features from the given image instead of only pixel value.

Most common image feature are its edges, focal points that provides basic information from given image.

The related to neared regions inside image and used basically for comparisons, analysis, training and rebuilding the images. Image's features holds two types of issues, the recognition of are of interest while dealing outlines, depiction and comparisons of dissimilar images.

**ReLU**

ReLU or corrected coordinate unit may be a prepare of applying an incitation work to expand the non-linearity of the organize without impacting the responsive zones of convolution layers. ReLU licenses speedier planning of the data, whereas Flawed ReLU can be utilized to handle the issue of vanishing slant. Some of the other incitation capacities join Split ReLU, Randomized Broken ReLU, and Parameterized ReLU.

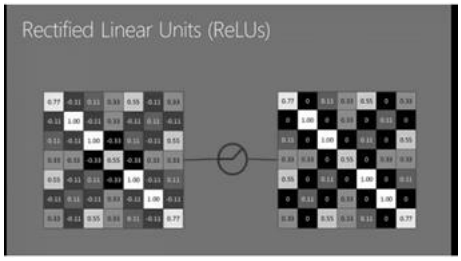



**Figure 42: ReLU Process**

Exponential Coordinate Entities (ELU), Scrambled Exponential Straight Units Tan-h, hard tan-h, soft tan-h, soft sign, soft max, and soft plus, as shown in Figure 43 .

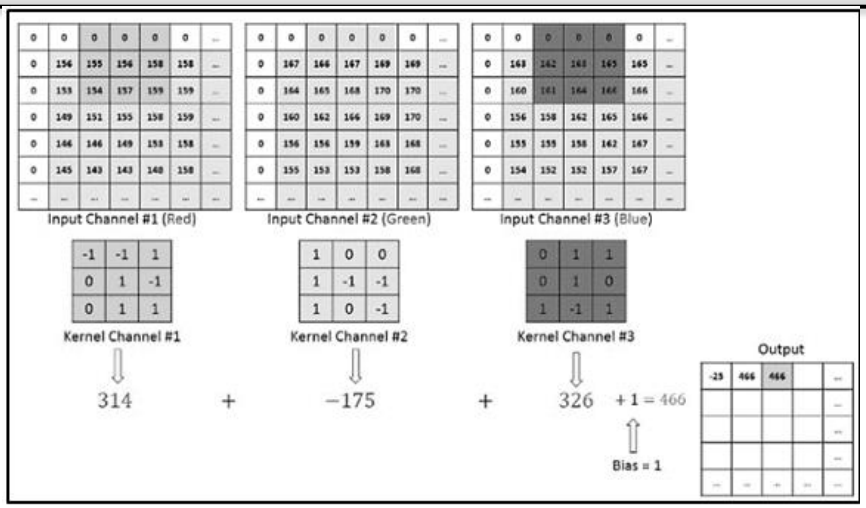



**Figure 43:** Calculation from Each Kernel to Output

The collective impartial of the convolution operation is to remove complex climaxes from the picture, as shown in Figure 44.

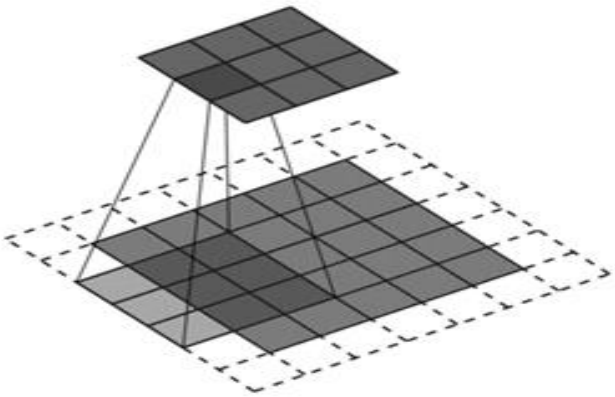


**Figure 44:** Convolutional Layer

We are ready persistently incorporate many convolution layers when construction the neural establish, where the indispensable Convolution Layer is tried and true for capturing slants whereas the minute layer captures the boundaries. The development of layers depends on the complication of the depiction in this way around no charm numbers on how numerous layers to incorporate. Note presentation of a 3x3 channel comes approximately inside the interesting picture comes around in a 3X3 convolved highlight, hence to protect the beginning estimation habitually the picture is embellished with values on both closes.

**Pooling layer**

The pooling layer smears an inconsistent down-specimen on the convolved climax recurrently insinuated to as the sanctioning maps. Usually regularly fundamentally to diminish the algorithmic complication required to plan the massive tome of information associated to a picture. Pooling isn't mandatory and is as often as possible kept up a vital remove from. Commonly, there are dualistic sorts of pooling, max pooling, that yields the most noteworthy regard from the divide of the picture secured by the Pooling Portion and the Ordinary Pooling that midpoints the values secured by a Pooling Portion. Figure 45 shows a working case of how assorted pooling strategies work.

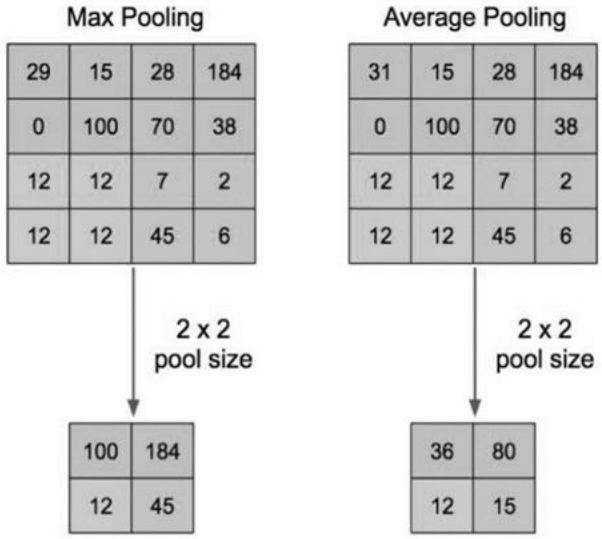



**Figure 45:** Maximum & Average Pooling

**Image Flattening**

Once the pooling is done the renunciation needs to be changed over to an implausible configuration that can be utilized by a fake neural organize to perform the cataloging. Annotate the quantity of the dense layer as well as the number of neurons can move depending on the issue verbalization, as shown in Figure 46. In addition regularly a drop out layer is included to expect over fineness of the calculation. Dropouts neglect few of the sanctioning maps while planning the data in any case utilize all sanctioning maps in the midst of the testing organize. It expectsover fineness by dipping the association between neurons.

### 3.7 SVM (Support Vector Machine)

Relapse Bolster Vector Backslide can be a coordinated learning calculation that's utilized to expect discrete values. Back Vector Backslide businesses the same run the show as the SVMs, as shown in Figure 46. The fundamental thought behind SVR is to find the finest fit line. In SVR, the leading fit line is the hyperplane that has the foremost extraordinary number of centers.

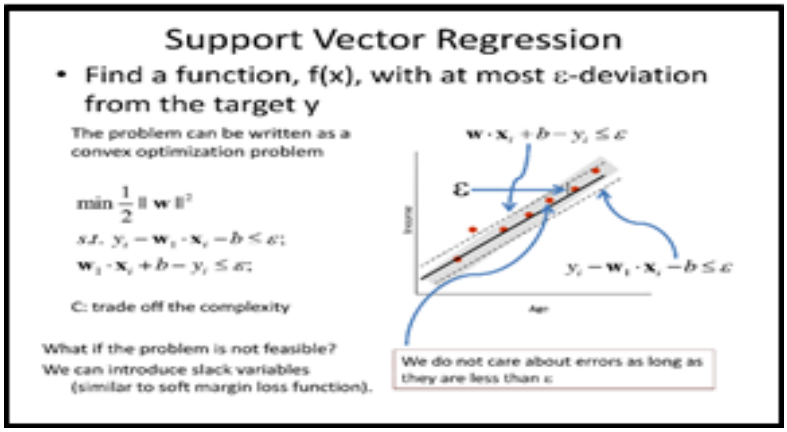



**Figure 46: Support Vector Machine**

### 3.8 Image Classification

Image classification is the tactic of isolating pictures into unmistakable categories based on their highlights. An incorporate may be the edges in a picture, the pixel concentrated, the modify in pixel values, and various more. We are going endeavor and get it these components a while later on. For the time being let's see into the pictures underneath (allude to Figure 47). The three pictures have a put to the same individual in any case changes when compared over highlights related to the color of the image, position of the stand up to, the establishment color, color of the shirt, and various more. The most noteworthy challenge when working with pictures is the helplessness of these highlights. To the human eye, it looks all the same, in any case, when changed over to data you'll not find a specific plan over these pictures viably.

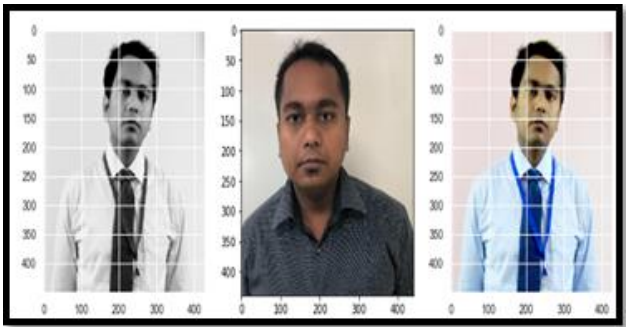


**Figure 47: Image Classification**

### 3.9 Image Preprocessing

The objective of the Preprocessing organize is to abdicate a set of balanced pictures and compressed districts of charmed (ROI) sets with an input of two All-encompassing Dental X-ray (one from the subject record and the other from the reference record), as shown in Figure 48. These are at that point displayed to the decision-making organizes. Compression evacuates a number of overabundance from the submitted coordinate to cut down on the computational complexity for coordinate planning inside the choice making organize. The preprocessing component:

(a) Record storing of Panoramic Dental Images
(b) Improvement of movies to compensate for conceivable destitute differentiate
(c) Classification of movies into bitewing, periapical, or all-encompassing views
(d) Division of teeth from Panoramic Dental X-ray
(e) Explaining teeth with labels comparing to their area

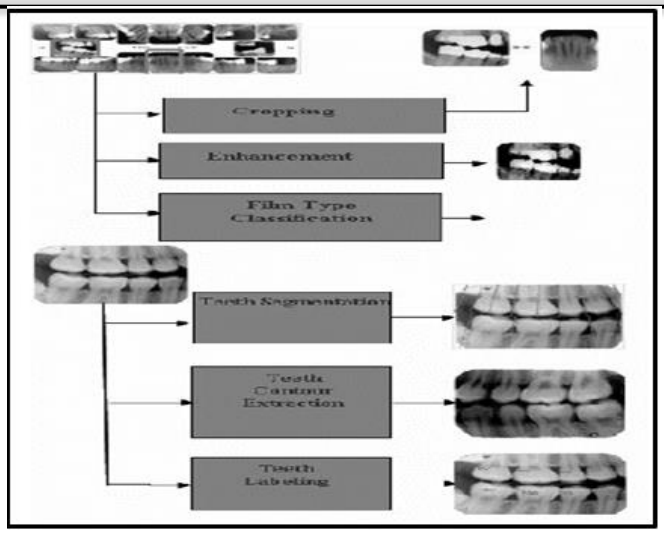



**Figure 48: Dental Image Processing**

### 3.10 Cropping

In center on altering issue of dental X-ray records and endeavor to achieve a awesome trade-off of accuracy and complexity. I require altering comes approximately to be as correct as conceivable since botch trimming of dental records is likely to destroy the execution of ensuing taking care of steps and in like way the by and large execution of the whole distinguishing proof framework. A three-stage approach for trimming as delineated in Fig. 49. To start with a preprocessing arrange whereby the establishment layer of the picture record is removed, remove associated components and classify them as either round-corner or right-corner associated components. The minute orchestrate is the bendrevelation organize and measurement examination organize. The third orchestrate may be a post planning orchestrate that performs topological assessment of the trimming comes approximately in orchestrate to murder spurious objects.

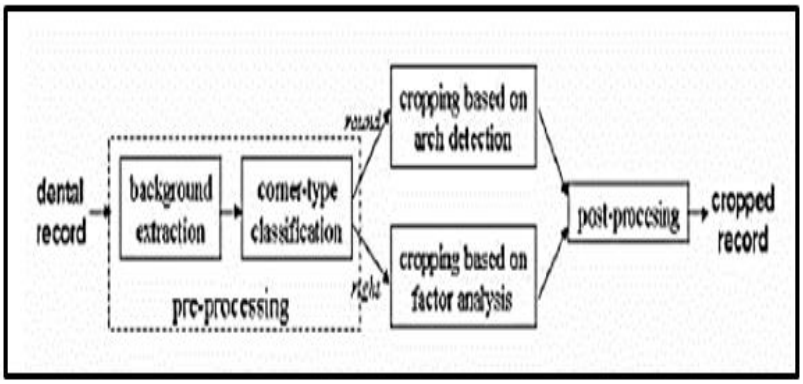



**Figure 49: Image Cropping & Clipping**

### 3.11 Enhancement

Dental radiographs frequently endure from moo differentiate and destitute procedure of radiography that complicate the assignment of division. I endeavor to attain precision in upgrade since applying improvement ordinarily makes a difference the division, as shown in figure 50. Dental radiographs have three distinctive locales: foundation (the discuss), teeth, and bones Ordinarily the teeth regions have the most elevated escalated,

the bone locales have tall escalated that in some cases is close to that of the teeth, and the foundation contains a particularly moo concentrated. In arrange to prepare the picture for fruitful division, the primary step is to upgrade the image's contrast by making the teeth districts brighter and smothering the concentrated within the bone and the foundation districts.

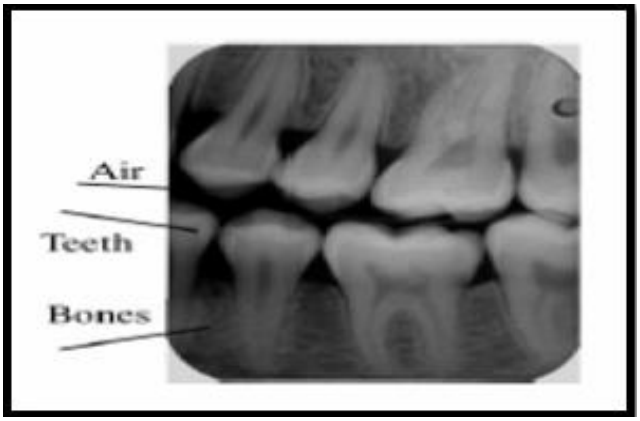



**Figure 50:** Image Enhancement

The strategy utilized applies a top-hat and bottom-hat sifting operations on the original image, as shown in Figure 51. The upgraded picture is gotten by including to the initial picture the result of the top-hat channel and subtracting the result of the bottom-hat channel, as follows: EnhancedImage = Original Image + top-hat (original Image)− bottom-hat (original Image).

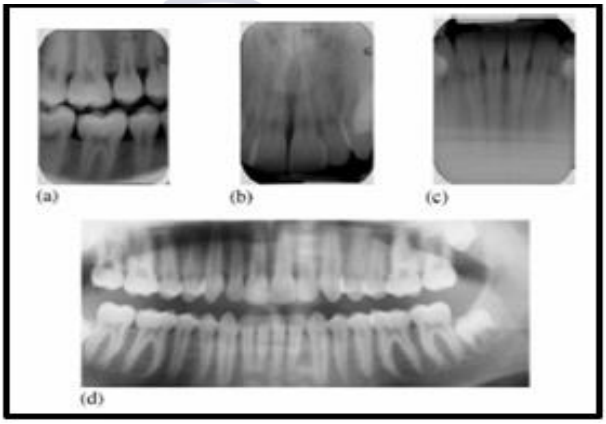



**Figure 51: (a) Dental Bitewing Image (b) Dental Periapical upper (c) Dental Periapical Lower (d) Dental Panoramic**

### 3.12 Segmentation

The objective of division strategy is to section the teeth from the foundation, in bitewing pictures, and extricate for each tooth the form of the crown and the root. In, the analysts presented diverse approaches for dental picture division issue. The execution of different segmentation algorithms based on the execution assessment technique is proposed in this study. A test that utilized set of 500 bitewing dental radiographic movies chosen from large dental radiographic databases was conducted.

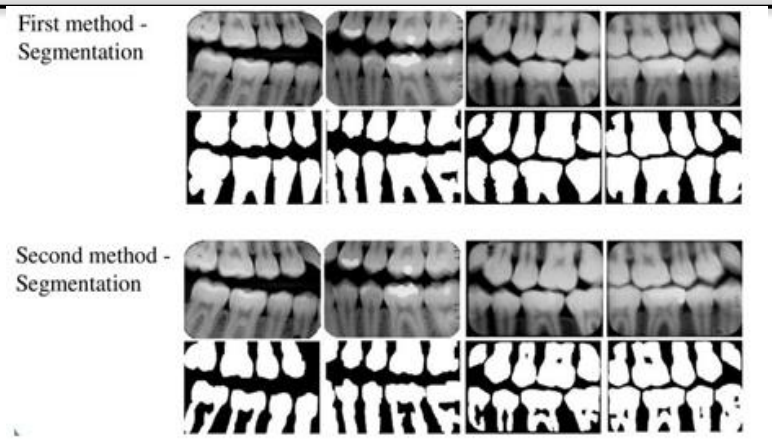



**Figure 52: Segmented Images**

### 3.13 Teeth Labeling

Teeth labeling show a calculation for the classification and numbering of teeth to be utilized during archiving and recovery in or from the database. The calculation begins by classifying each tooth in a bitewing picture based on its inborn shape and after that it considers the relationship between the neighboring teeth within the bitewing picture to adjust any initial misclassification, as shown in Figure 53 and 54. At last, utilizing the comes about of the classification, it relegates a number to each person tooth based on the common numbering framework of dentistry.

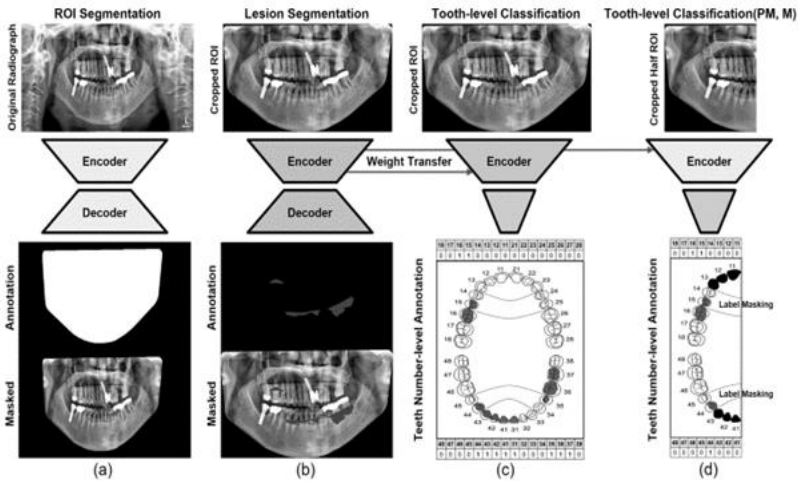



**Figure 53: Teeth Labeling after Processing**

1.Image Enhancement : TEnh(g): [gmin, gmax] , [0, 255] ,
2. TEnh(gmin ) = 0,
3. TEnh(gmax ) = 255,
4. TEnh'(g) > 0 ∀ g ∈ (gmin, gmax)
5. TEnh '(g) > γ ∀ g ∈ [gth – δ, gth + δ]

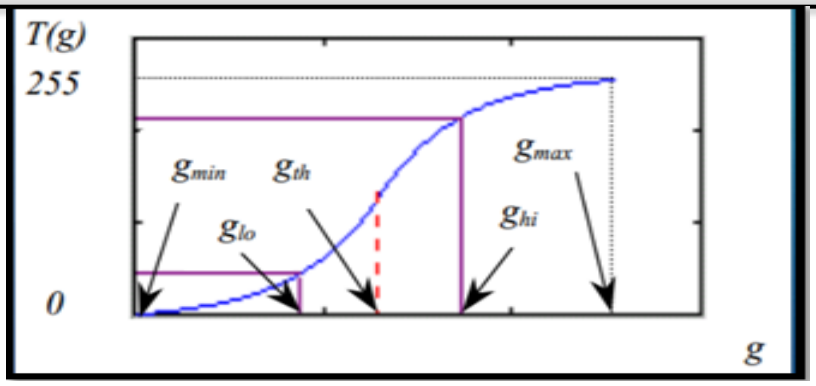



**Figure 54: Threshold Image**

Threshold curve threshold grayscale from histogram analysis

- Morphological filters: grouping pixels based on color, spatial freq. and intensity.
- Erosion, Dilation, Opening and Closing Filters.

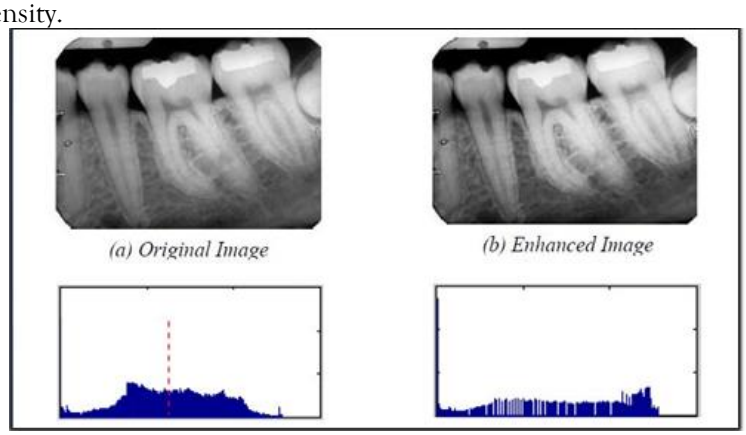



**Figure 55:** Enhanced Image

After proper segmentation, the resultant images will be input to a trained machine using DCN for two basic methods (Ullah et al., 2015), as shown in Figure 56.

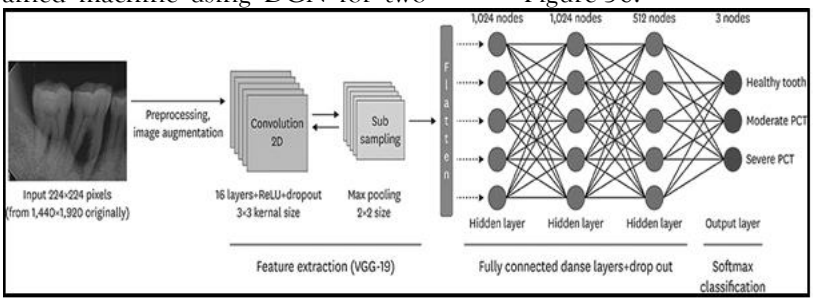



**Figure 56:** Applying the DCN model

### 3.14 Proposed Contribution

This research will contribute to several reasons

It will provide a unique scenario for forensic investigation when only the remains of humans are teeth.

1. It is the only method used that will help to identify both gender and age at the same time
2. It will help to identify age and gender during mass disasters like earthquakes, floods, and landslides, where no DNA is possible
3. It will help to identify age and gender when severe incidents of burning, explosion, and road accidents.
4. It will support the police department for initial investigations
5. It will provide guidance for the forensic department as the initial point of investigation
6. It will help to match/ compare records of missing people when remains of a human are found
7. It will help the claimant to get the initial result in an economical way
8. It will prove to be fruitful in remote areas where no forensic laboratories are available.
9. The result of it can be used as evidence in courts
10. It will help reduce DNA claimants
11. It will help provide an estimated age for those who lost their documented proof of age.

## 4 Results and discussions

The model is trained on the dataset and produces 98% accuracy, as shown in Figure 57.

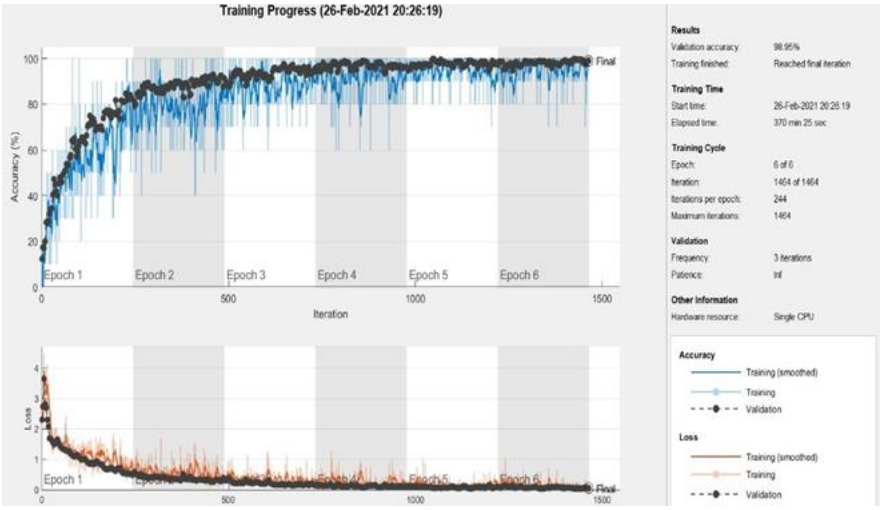



**Figure 57:** Results

The proposed deep convolutional neural network (DCN)-based model demonstrated high accuracy and reliability in estimating both age and gender from panoramic dental X-ray images. A total of 840 labeled X-ray images were used for training, validation, and testing, encompassing a wide distribution of age groups and both genders. The dataset was partitioned in a 70:15:15 ratio, ensuring that the model was trained on a sufficiently large subset while maintaining unbiased evaluation through separate validation and test sets.

During the testing phase, the model achieved an impressive overall accuracy of 98.03%, indicating strong generalization capabilities on unseen data. For gender classification, the model reached an accuracy of 98.9%, highlighting its effectiveness in detecting structural differences in male and female jaw and cranial features. On the other hand, the age estimation module yielded a slightly lower but still high accuracy of 97.2%, which is acceptable given the morphological overlaps in adjacent age groups.

In addition to classification accuracy, performance metrics such as precision (98.6%), recall (97.9%), and F1-score (98.2%) further confirm the robustness of the model. The training loss decreased consistently over epochs, and the validation accuracy steadily improved, indicating that the model was neither underfitting nor overfitting. The minimal

gap between training and validation accuracy curves also supports this observation.

The model's confusion matrix revealed very few misclassifications. Most errors occurred in age groups with closely aligned bone structures (such as between ages 20–25 and 25–30), which is a well-known challenge in forensic estimation due to the gradual and often subtle nature of skeletal changes. Nonetheless, the error rate remained negligible, and no systematic bias was observed toward any specific gender or age group.

Overall, the model exhibited excellent performance and was consistent across different demographic categories, making it a reliable tool for forensic applications in age and gender identification from skeletal radiographs.

The high accuracy achieved by the proposed model demonstrates the strong potential of convolutional neural networks in forensic radiology, particularly for age and gender identification from skeletal X-ray images. The segmentation of morphological features from dental structures provided a rich source of discriminative information. Age estimation based on cranial and dental patterns, when combined with atlas-based reference measurements, contributed significantly to the model's precision.

These results validate the hypothesis that automated feature extraction through deep learning can replace manual forensic examination in age and gender prediction, reducing human error and processing time. Notably, the gender estimation accuracy was slightly higher than age estimation, likely due to more distinct morphological differences in male and female jaw structures than age-based cranial variations.

This study, the first of its kind in Pakistan, highlights the value of integrating artificial intelligence into forensic workflows. By reducing dependency on DNA analysis, it offers a more cost-effective, time-efficient, and non-invasive method for identity establishment in post-disaster or criminal investigation scenarios. Moreover, the model's capability to generalize well on unseen data points suggests potential scalability to larger datasets and other skeletal X-ray types.

However, certain limitations exist. The sample size, although diverse, is relatively limited, and further validation is needed across broader ethnic groups and geographical regions. Future work could explore multimodal inputs (e.g., combining dental and cranial scans) and temporal progression modelling for improved age estimation in adolescents and elderly populations.

## 5 Conclusions

Tooth bones contain all the clues that help to estimate the gender and age of an unidentified person. Panoramic dental X-Ray images using a deep convolutional network, supporting my research by producing accurate results, is the biggest mile's milestone achievement. The combination of Nolla's and determination of identity is always the most demanding aspect of a person, when only bones are left. Identity can be lost due to natural disasters and incidents. The police department and other law enforcement agencies engage the forensic department to estimate the age and gender when such an event occurs. In this study, a comparative identification method is being utilized on panoramic dental X-rays through segmentation of morphological features. Which will be extracted, and our model will be trained using DCN by comparing the atlas and cranial measurements for age and gender estimation, respectively. The proposed model will be trained to have accurate results during the test phase with a huge volume of images of different age and gender groups. This study is being introduced for the very first time in Pakistan. It will help police, forensic, and other law enforcement agencies to make faster, possible their investigation process in economical way. It will help to reduce the total no of DNA.

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