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Annals of Forensic Research and Analysis

Review Article

Forensic DNA Phenotyping (FDP): A Potential Method of Using Biological Samples to Predict an Individual's Externally Visible Characteristics

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Submitted: 12 November 2025

Accepted: 29 December 2025

Published: 30 December 2025

ISSN: 2378-9476

Keywords
- Forensic DNA phenotyping
- Short tandem repeat
- DNA phenotyping

Abstract

A new approach called Forensic DNA phenotyping (FDP) is an emerging technology which uses short tandem repeat (STR) to identify individuals. Next generation sequencing (NGS) is its only foundation. The practice of predicting an organism's phenotype only from genetic data gathered through DNA sequencing or Genotyping is known as DNA phenotyping, another name for it is molecular photo fitting. Each individual is considered genetically unique, except monozygotic twins. This technique illustrates an individual's externally visible characteristics (EVCs) from DNA which is obtained from biological samples. Eye, hair and skin colour can now be predicted reliably and accurately. Due to a lack of understanding of phenotypes, FDP has not yet been used on a regular basis in the field of forensic research. FDP will most likely have a bigger impact on criminal casework in the near future, notwithstanding recent advancements.

INTRODUCTION

The process of using DNA taken from human biological samples taken at crime scenes to forecast an individual's outwardly visible characteristics (EVCs), such as age, look, and biogeographic origins, is known as forensic DNA phenotyping (FDP). Since the sample donor is unknown to the investigating authorities and its STR profile cannot be used for comparative mathing, FDP is used in criminal instances when forensic STR-profiling yields no matches. If the offender is local, another consideration is the frequency of the anticipated EVC feature in the area where the offense was committed. If the unknown culprit is from the area where the crime occurred, predicted EVC attributes that are less prevalent there will aid the police investigation more than common ones in identifying the offender. Combining FDP with patrilineal familial search is a useful strategy in cases involving unknown male offenders, where only individuals who satisfy the FDP outcome are asked voluntarily to participate in the YSTR profiling. Compared to DNA mass screening or DNA dragnets used alone, this combination strategy enables the focus on a smaller number of volunteers who fit the FDP outcome.

Milica van Doorn's murder and rape case in the Netherlands serves as an example of the effectiveness of this combined strategy. The average prediction accuracy estimates derived from the prediction models' validation show whether a tool or prediction model is accurate enough for realworld use. Though they do so in fewer people than with accurate models, even models with lower average accuracy can produce high probability in some people.

Current appearance DNA prediction techniques provide probability of trait categories for all appearance traits for which genotyping tools have DNA predictors in a realistic casework application. Since the science of continuous appearance prediction from genetic data is still in its infancy or is plagued by the enormous number of DNA predictors required, appearance DNA prediction in forensic applications up to this point only represents categorical prediction. When determining biogeographic ancestry from crime scene DNA, a likelihood ratio (LR) framework is usually used, which is similar to estimating a probability. The prediction model in DNAbased age prediction provides an age estimate, with the error represented by the prediction model's average error.

Therefore, FDP not only gives information on the most likely geographic region of biogeographic ancestry, the most likely age, and the most likely category of all appearance attributes for the unknown sample donor, but it also offers information on the mistakes of these DNAbased predictions.

Although the mistake in an eyewitness report of any particular case is entirely unknown, this represents an advantage over eyewitness descriptions (where available), which are known to be extremely subjective and subject to alter over time. Police investigators can determine how much weight to give the generated FDP information in the inquiry based on the size of the probability or LRs found in any particular case. Whether directly or indirectly, FDP always uses reference data. Directly, using reference population sample data and case sample data for inference analysis, as is the case with the majority of biogeographic ancestry prediction programs. indirectly, as in the case of age and appearance prediction, where the prediction models use the reference data to determine the probabilities, but not by the prediction tools directly. Therefore, when FDP results are presented to the investigative authorities, reference data should always be described along with the forecast outcome.

SIGNIFICANCE OF STUDY

- In order to help investigators, prioritize leads and concentrate their search, FDP can offer a physical description of an unidentified suspect.
- The likelihood of identifying a suspect can be improved by combining FDP with conventional forensic DNA analysis.
- FDP can be used on DNA evidence that has been around for decades, yielding fresh leads and possibly resolving cases that were previously unsolvable.

REVIEW OF LITERATURE

Forensic DNA phenotyping: predicting human appearance from DNA" by Carles [1]

With an emphasis on its application in predicting physical characteristics like as skin tone, eye color, and hair color from DNA, this paper explore the methods and tools that underpin forensic DNA phenotyping (FDP). Even from damaged or low-quality DNA samples, forensic investigators can produce phenotypic profiles.

Forensic DNA phenotyping: A review of available technologies and applications

The current status of forensic DNA phenotyping, which includes a range of genetic markers used to predict physical attributes including pigmentation, hair structure, and even facial features, is thoroughly evaluated in this review paper [2].

The role of forensic DNA phenotyping in the investigation of cold cases

When conventional DNA profiling is unable to find any matches in current databases, the authors explain how phenotyping can help reduce suspect pools or generate fresh investigation leads [3].

Advances in forensic DNA phenotyping and its implications for the justice system

This article offers a thorough examination of the developments in forensic DNA phenotyping and its growing significance in the legal and law enforcement fields. The genetic methods for trait prediction and the moral and legal ramifications of using phenotypic data in criminal investigations are covered in the review [4].

Ethical considerations in forensic DNA Phenotyping

Forensic DNA phenotyping's ethical and social ramifications are the main topic of this review. Concerns about permissions, privacy, racial profiling, and the wider ramifications of using genetic information to predict physical appearance in criminal investigations are also covered [5].

DISCUSSION

Previously mentioned, FDP has ethical, societal, and legal ramifications. While FDP is permitted in certain nations without legal restrictions, other nations have updated their forensic DNA laws in recent years to permit and control FDP. Since the science of continuous appearance prediction from genetic data is still in its infancy or is plagued by the enormous number of DNA predictors required, appearance DNA prediction in forensic applications up to this point only represents categorical prediction.

However, since it enables the exclusion of people who do not share similar characteristics, such as members of minority groups, this does not imply that forecasting common features is useless. The ultimate use of the FDP results during the police inquiry is another factor that determines the practical success of the program. The risk of racial profiling is one of the critical ethical issues regarding forensic DNA phenotyping. For example, having phenotypic motives such as skin pigmentation and ancestry could lead to discrimination or stereotyping

in criminal background checks because such features are often connected to specific racial groups. Through the reduction of the number of possible suspects to a group of individuals who math the EVC information predicted from the crime scene DNA, FDP seeks to provide investigatie leads to assist in the search for unidentified criminals. As a result, FDP permits targeted police inquiries based on data taken straight from the supporting documentation. FDP applications are always followed by forensic STR profiling for final person identification because present FDP tools are unable to deliver appearance on the individual specific level, which is also unlikely to become available in the near future.

The combination of all three FDP components is the most informative method to identify unknown perpetrators using DNA because appearance, ancestry, and age alone describe an individual's EVCs, and because certain appearance traits depend on specific biogeographic ancestries and/or an age range. Based on appearance, ancestry, and age prediction the degree of specificity, precision, and dependability with which age, appearance, and ancestry can be inferred from crime scene DNA will ultimately determine the practical success of FDP in criminal casework. FDP tools typically comprise two parts:

i) a multiplex genotyping tool:

that has been forensically validated to analyze all predictive DNA markers in the crime scene sample using forensically appropriate DNA technology that permits low quality and low quantity DNA analysis,

ii) a prediction tool

that uses a validated prediction model to determine the likelihood of appearance and ancestry prediction as well as to estimate age from the epigenetic data established with the multiplex genotyping tool from the crime scene DNA.

CONCLUSION

An emerging tool for human identification is forensic DNA phenotyping, and numerous studies are being conducted to improve and develop this method. The goal of FDP approaches is to identify unknown people by determining their age, gender, size, and other EVCs. Despite being a potent tool in the field of forensic science, its advancement has been impeded by concerns about privacy invasion, data storage, and surveillance. To improve forensic caseworks and replace the conventionally used protocols, forensic researchers must continue to create FDP markers and analytical tools. The application of FDP in forensic casework will be improved by the use of uniform regulation and utility of FDP data in conjunction with other supporting evidence, which will aid in the investigation of crimes.

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