HUGINEXPERT
The leading decision support tool

Whose DNA?

This white paper illustrates how to use HUGIN Bayesian network software for forensic identification problems using DNA profiles.

Bayesian networks are ideal for expressing, manipulating, and resolving identity questions in a variety of forensic contexts, including identification based on DNA evidence.

Using HUGIN software forensic science service organizations can develop and integrate advanced probabilistic evidence calculations in their own systems for analyzing DNA and calculating probabilities of identity. Computations are made quickly, reliably, and efficiently – even in complex cases involving several and possibly mixed traces of DNA, combining evidence from alternative sources.

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DNA profiling has become a central tool for dealing with identification issues and other forensic queries: in establishing paternity and family relationships, in the context of immigration control and archeological research, and in identifying potential offenders based on traces of DNA found on crime scenes.

HUGIN software represents the state-of-the-art in specifying, manipulating and calculating probabilities in Bayesian networks, and has a wide range of applications in forensic services. This white paper illustrates the uses of HUGIN Expert software in forensic contexts.

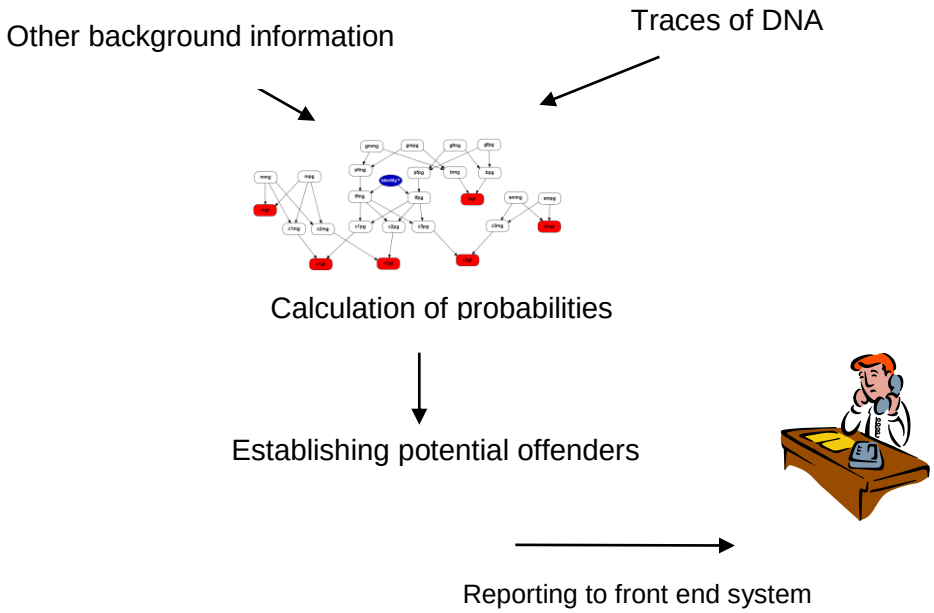

Figure 1: An example illustrating how forensic services can use HUGIN software to establish potential offenders in a criminal case.

HUGIN software is an advanced tool for handling Bayesian networks. As such it can be used to compute the probability that a specific individual has contributed to one or more mixed traces of DNA. It can also be used to identify the most probable DNA profiles for a set of unknown contributors to a mixture. Figure 1 illustrates how HUGIN software may be integrated into an existing system for managing results from DNA analyses.

The flexibility of the HUGIN software enables the advanced decision support capabilities of the tool to be integrated into IT environments in different ways. And because the approach is model-based, the same network can be used to answer a multitude of queries in a coherent way, making it useful in all phases of an investigation, such as planning, searching for and establishing evidence.

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Figure 2 illustrates a network in a case of identifying the brother of a man who has fathered three children with two different females. Observations may be available on the genotypes of each of the females, all three of the children and the brother, indicated in red.

The model describes the family relations between the individuals involved, and thus represents the genotypes of the grandparents, to capture the relationship between the brother and his nephews/nieces. The network is *object-oriented* in the sense that every oval node itself

represents a potentially complex network, for example describing the transmission of genes from parents to children in the meiosis.

The network can now be used for a variety of purposes. If DNA profiles for the observable individuals have been obtained, evidence can be entered and propagated, and the query-node "Identity?" will contain the probability that the individual to be identified is the alleged brother. Alternatively, if queries or genotypes of specific individuals are hypothesized, the probability distribution over genotypes of other individuals can readily be computed. The expected amount of information in a specific node, e.g. the genotype of the third child and/or the second mother can be found, etc.

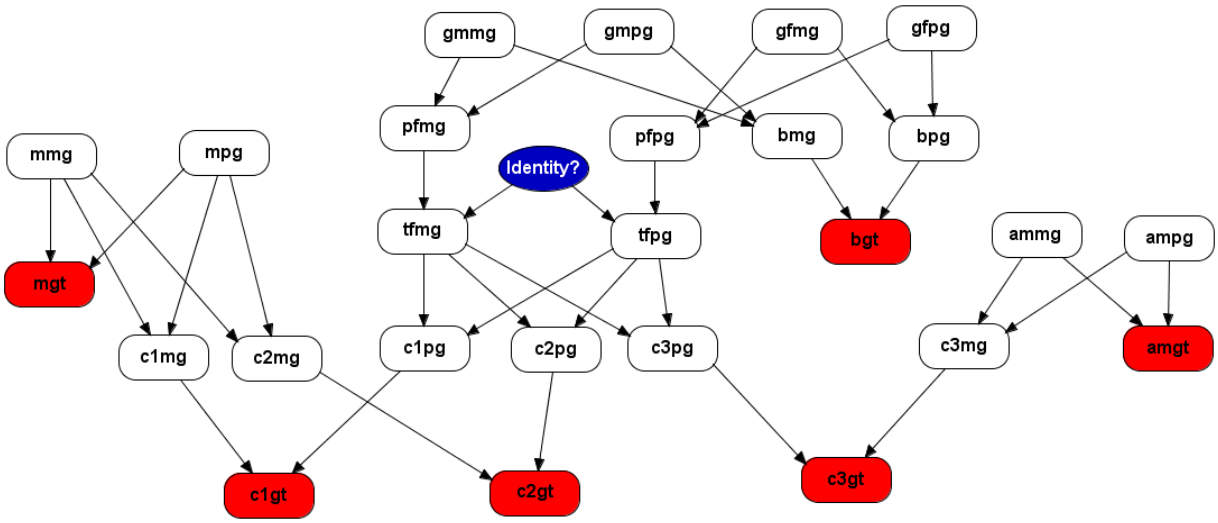

Figure 2: Network for determining the identity of an uncle of three children with a common father and two different mothers.

The object-oriented interface enables the user to build small modules representing various complications in the network. For example, some of the DNA-profiles may only be known through mixtures, or with high probability of error through low-copy numbers, possibly of mutation during meiosis, allele dropouts, etc. Each of these specific modules can then be combined appropriately to form the joint network representing the features of a given case.

Benefits of an Identification System Based on HUGIN Software

A number of important benefits are available:

- More accurate identification and high model performance
- Straightforward integration of technology into existing IT platforms
- Model update is easy and analysts are in full control of the process
- Better utilization of expert knowledge

System Integration

One of the major advantages of HUGIN software is that it integrates seamlessly with existing IT environments. The advanced decision support capabilities of HUGIN software integrates with both existing and new environments.

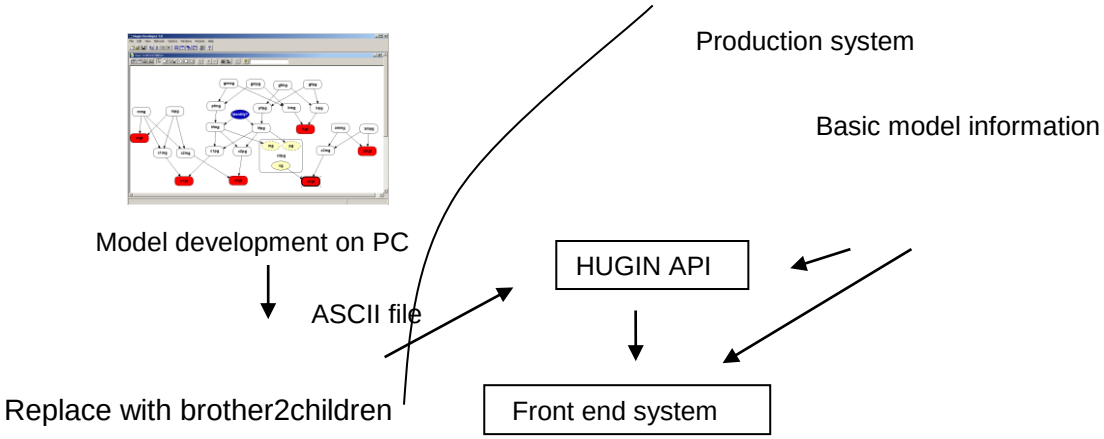

Figure 3: Seamless system integration.

Using HUGIN Application Programming Interfaces makes the system integration process simple and efficient. Figure 3 illustrates the typical setup. The model development process proceeds on standard PC platforms using HUGIN Graphical User Interface. Each model is stored in an ASCII text file. The file is transferred to the production system. On the production side existing IT systems interact with the model through the HUGIN API feeding information into the model and receiving results of inference using a well-defined set of flexible functions.

Key Advantages of HUGIN Software

HUGIN software has a number of key advantages over competing systems:

- Integrates different sources of information including subject matter expert knowledge, and case-specific complications.
- Calculations are highly efficient supporting real time inference.
- Model integration and maintenance is easy.
- An intuitive graphical specification makes the model an efficient tool for communication between forensic scientists, subject-matter experts and others who provide evidence in a case.
- Flexible knowledge representation. Models can easily be extended with additional complications and parameters of a model can be adjusted with minor effort.

Key Product Features

Figure 4 shows the HUGIN Graphical User Interface. This interface supports analysts and knowledge engineers in the model development process.

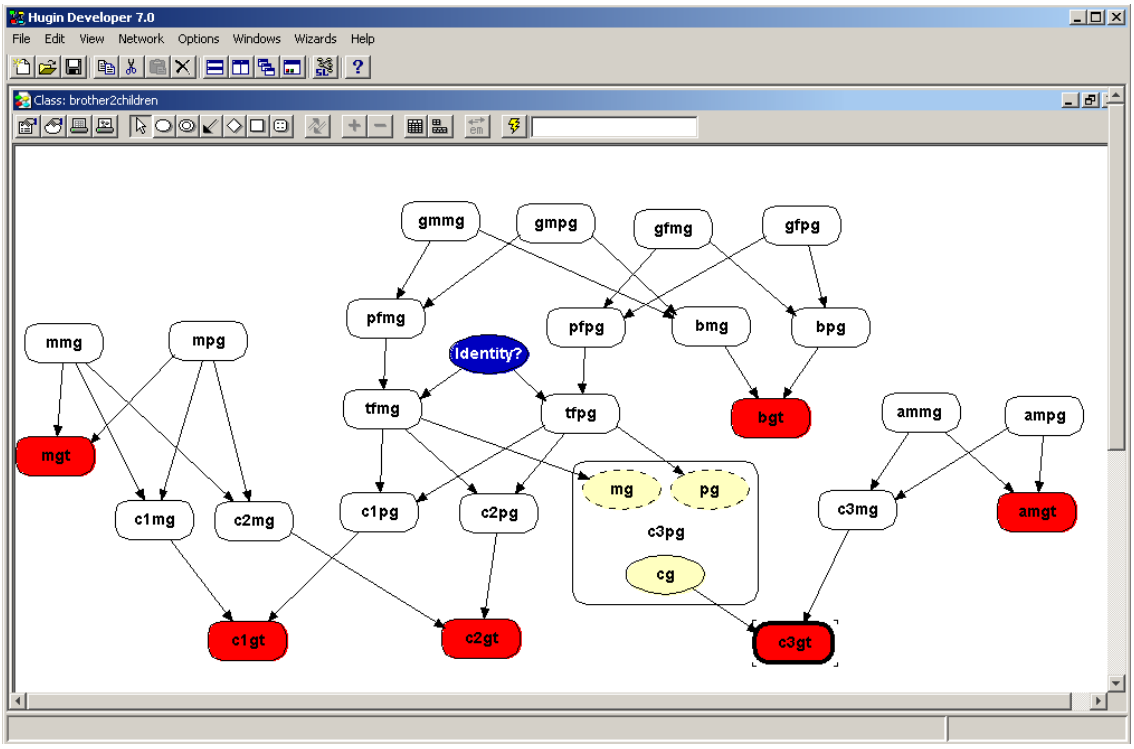

Figure 4: HUGIN Graphical User Interface showing the default model.

- User-friendly graphical interface
- Highly efficient inference engine
- Easy integration of models into existing systems
- Easy maintenance of models and implementations
- Flexible Application Programming Interfaces to major programming languages (C, C++, Java, .NET and VBA for Applications)

Products & Services

The HUGIN software consists of model development and deployment tools. The HUGIN Graphical User Interface supports the analysts in the model development phase, while the HUGIN Decision Engine comes with Application Programming Interfaces for major programming language enabling efficient integration into new and existing IT systems. HUGIN software has been implemented on wide range of diverse software and hardware platforms including servers, desktop & laptop PCs and PDAs running under Microsoft Windows, UNIX and Linux operating systems.

HUGIN services consist of training, consulting and technical support. With basic training in the technology and tools, analysts are equipped with a sufficient background to develop sophisticated models using HUGIN software. To assist in the model development and integration phase HUGIN Expert A/S offers professional consultancy services.

About HUGIN EXPERT A/S

HUGIN Expert A/S is a provider of predictive analytic software for building model-based risk analysis and decision support solutions that can handle uncertainty. HUGIN EXPERT A/S was established in 1989 and is headquartered in Aalborg, Denmark. Clients use HUGIN tool to create intelligent decision support solutions for fraud detection, credit default prediction, operational risk management, forensic identification, medical diagnosis, health monitoring, risk analysis, data mining, troubleshooting, safety assessment and more. For more info visit **www.hugin.com**.

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