

1.2 Expert diagnostic system for patients with vegetative-vascular dystonia

In medical practice, achieving accurate diagnosis and appropriate treatment prescription remains a significant challenge, often complicated by factors like patients' inaccurate symptom descriptions and physicians' limited expertise in specific domains. This issue is particularly pronounced in neurology, especially in the diagnosis and treatment of vegetative-vascular dystonia, highlighting the complexities involved in managing this condition.

The contemporary landscape of computer technologies, alongside the expert systems developed upon their foundation, presents expansive opportunities for application within the medical domain. Specifically, the employment of expert systems for the diagnosis of neurological disorders has garnered increasing significance in recent years. This growing relevance is attributed to the unique capacity of these systems to assist in complex diagnostic processes. However, the challenges encountered in the development of intelligent diagnostic systems for neurological diseases primarily stem from the inherent difficulty in systematizing and formalizing the knowledge required for accurate diagnostics in this specialized field [16].

The deficiency of a precise methodological framework in diagnostic processes, coupled with the nebulous delineation of symptomatic profiles across diseases, engenders an equivocal and occasionally paradoxical depiction of the patient's pathological landscape. The integration of symptomatic and neurological assessments, the proficiency in differential diagnosis across analogous disorders, and the consolidation of clinical acumen into a unified system stand to substantially streamline the neurologist's diagnostic endeavors [17].

The constructed expert system is comprised of several integral components (Figure 1): the logical inference block, working memory also referred to as the database, the knowledge base, elements of knowledge acquisition, the explanatory component, and the dialogue component [18].

The database is designed to store both the initial and intermediary data pertinent to the task at hand. Concurrently, the knowledge base serves as a repository for production rules that encapsulate the expertise of seasoned and highly skilled physicians within the relevant domain. Using the foundational data from the working memory and the insights stored within the knowledge base, the logical inference block orchestrates a sequence of rules. When applied to the initial data, this sequence facilitates the resolution of the problem. The knowledge acquisition component streamlines the integration of domain-specific knowledge into the expert system, a process conducted by the expert physician. Meanwhile, the explanatory component elucidates the rationale behind the system's conclusions or its inability to make a decision, detailing the knowledge used in the process. This clarification aids in the system's validation by experts and bolsters user confidence in the outcomes. Lastly, the dialogue component is dedicated to establishing an intuitive interface for the physician, enhancing interaction throughout problem resolution, knowledge acquisition, and the explication of the system's findings.

The knowledge base within the expert system is constituted by an assembly of facts and production rules, which serve as the foundational elements for decision-making processes. The decision-making unit is tasked with delineating the methodology for the application of these production rules, thereby facilitating the precise diagnosis of patient conditions.

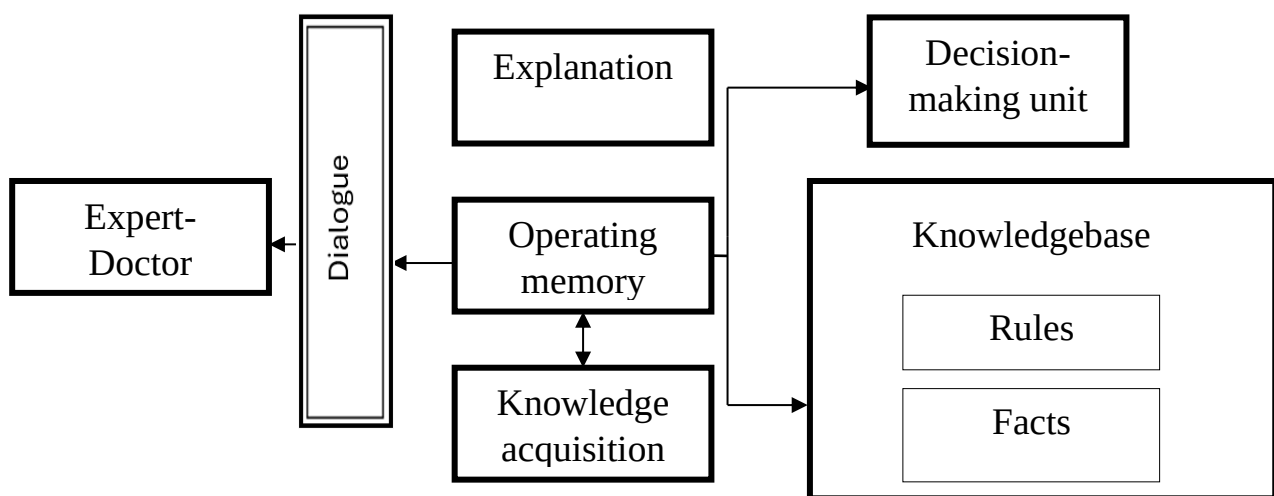


Figure 1. Structure of a generalized expert system.

The knowledge base incorporates a selection of facts that underpin its decision-making capabilities, exemplified as follows:

- The manifestation of a headache in a patient is correlated with increased irritability.
- The occurrence of a headache is associated with emotional instability in the patient.
- Vegeto-vascular dystonia is identified as a dysfunction within the autonomic nervous system.
- This condition plays a crucial role in preserving the homeostasis of the organism's internal milieu.
- Vegeto-vascular dystonia enhances the organism's ability to adapt to fluctuating environmental conditions through the mobilization of functional systems.
- Neuritis is characterized as an inflammatory condition affecting the peripheral nerves.
- Intercostal neuralgia arises from the compression or irritation of the intercostal nerves.
- A brain abscess is defined by the localized collection of pus within the cerebral tissue.
- Arachnoiditis describes a serous inflammation of the arachnoid, which is a membrane enveloping the brain or spinal cord.
- Sciatica is characterized as neuritis of the sciatic nerve, involving inflammation and pain along this nerve.
- Bacterial meningitis describes the inflammation of the brain's meninges, typically caused by bacterial infection.
- Mononeuropathy denotes isolated damage to individual peripheral nerve trunks, affecting nerve function.
- Depression is a psychiatric condition marked by persistent feelings of apathy, ennui, and anxiety, impacting an individual's mood and daily functioning.
- Syncope refers to a transient, acute vascular insufficiency leading to a brief loss of consciousness.

- Stone therapy, a therapeutic technique involving the use of heated stones, aims to alleviate stress, tension, and fatigue through massage.
- Neuritis, in a specific context, is defined as an isolated lesion of a single spinal or cranial nerve.
- Chronic cerebral ischemia is identified as a distinct form of cerebral vascular pathology, characterized by a slowly progressive, diffuse insufficiency of blood supply to the brain tissue.
- Schizophrenia is a mental disorder known for its tendency towards a chronic progression, affecting a person's thinking, feeling, and behavior.
- The nerve cell, or neuron, represents the basic structural and functional unit of the nervous system, distinguishing itself significantly from cells constituting other organs and tissues.
- Nerve fiber is described as the axon of a nerve cell, comprising an axial cylinder encased within a myelin sheath.
- The central nervous system is comprised of the brain, housed within the cranial cavity, and the spinal cord, situated within the spinal canal.
- Brain death is defined as a state in which all brain functions cease irreversibly due to destructive or metabolic alterations in cerebral tissue.
- Anomalies refer to structural deviations from the norm, arising from disruptions in prenatal development. Echoencephalography is a method for detecting structural intracranial disorders using ultrasonic signals reflected at the boundaries of media with different physical characteristics.
- Meningitis constitutes an acute infectious pathology predominantly impacting the arachnoid mater and pia mater, the delicate membranes enveloping the human brain and spinal cord.

Part of the productive rules are as follows:

- IF (the patient has a sensation of headache with physical effort) OR (with coughing and sneezing)
THEN a neurologist should be consulted.
- IF the headaches first occurred after the age of 50

THEN is a sign of a very serious pathology.

- IF this is a sign of a very serious pathology

THEN the following diseases are possible: temporal arteritis, brain tumour.

- IF (the patient is under the influence of emotional stress) AND is subjected to (physical AND mental AND emotional overload AND feels exacerbation of neurological) AND somatic diseases)

THEN, because of these influencing factors, vegeto-vascular dystonia may develop.

- IF (patient feels short of breath AND has difficulty breathing AND rapid breathing AND excessive sweating) AND (bowel problems AND abdominal pain)

THEN all of these symptoms indicate that your nervous system needs help.

- IF (patient's legs are shaking) OR (seedy gait) AND (speech is very quiet AND monotonous) AND (there are significant mood swings emotionally).

THEN it suggests that the patient may be in the early stages of tremor palsy.

- IF (patient has loss of orientation) AND (depressive disorders) OR (rabies and seizures) AND (seizures)

THEN the patient has epilepsy.

- IF (patient is bothered by a feeling of dizziness) AND (frequent headaches) OR (nausea AND short-term seizures AND other generalised cerebral disorders)

THEN are all indications that the patient has a concussion.

- IF (patient has gastrointestinal disorders, constipation) OR (liquid stools, gallbladder dyskinesia, spastic pain), OR (dry skin AND sweating)

THEN the patient has dystonia.

- IF (the patient's head and neck muscles contract AND convulsively clench)

THEN the tense vessels stimulate the pain receptors.

- IF (patient has pain on one side of the head and face AND lasts 20 minutes to 2 hours)

THEN patient has histamine headache.

- IF (patient has inflammation of several peripheral nerves) OR (symmetrical nerve trunks on upper and lower extremities)
THEN the condition is called polyneuropathy.
- IF (patient has loss of consciousness, nausea) OR (vomiting AND retrograde amnesia)
- IF the patient has a concussion.
- IF the patient has a speech disorder due to damage to certain areas of the cerebral cortex AND loss of the ability to use words and phrases as a means of expressing thought.
- THEN the patient has aphasia.

A logical inference algorithm constitutes a computational mechanism designed to emulate the process of human reasoning. It systematically operates on a foundation of existing knowledge and data, utilizing this information to extrapolate new data from the synthesis of knowledge and other data present within the working memory. This process facilitates the derivation of conclusions that were not explicitly stated within the initial dataset, thereby augmenting the decision-making capabilities of the system in which it is implemented.

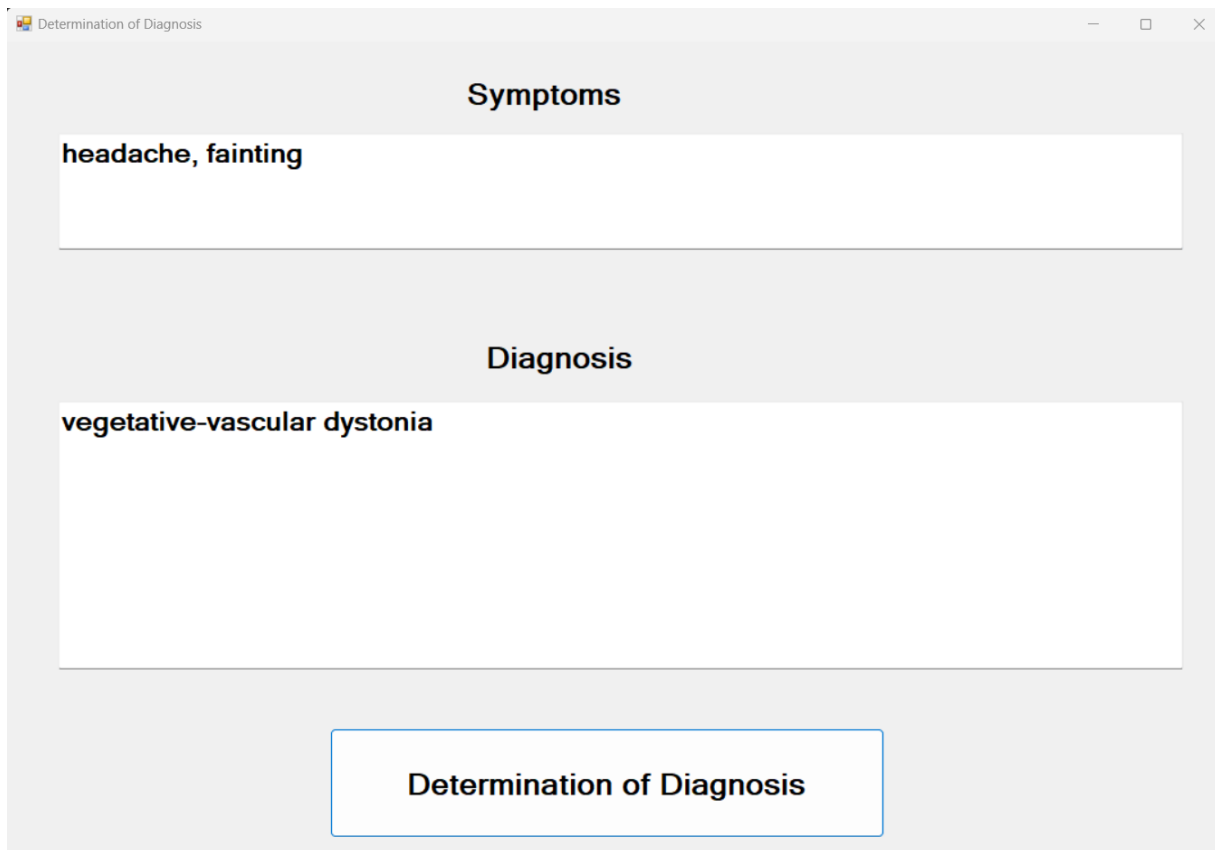
The logical inference mechanism performs the following functions:

- forms and processes active facts for a particular situation;
- determines the order of selection and application of facts and production rules.

The mechanism of logical inference can be visualized as four sequential processes:

- selection of active productive rules and facts;
- ranking of production rules by priorities;
- conflict resolution;
- diagnosis.

The activation protocol for this procedure is initiated upon the physician's entry of a minimum of one symptom, followed by the engagement of the "Determine Diagnosis" button within the designated interface window (figure 2).



Symptoms

headache, fainting

Diagnosis

vegetative-vascular dystonia

Determination of Diagnosis

Figure 2. Diagnosis determination form.

In the realm of logical inference, two predominant methodologies are identified: forward chaining and backward chaining. Forward chaining involves a progression from known facts towards a deducible conclusion, whereby the inference process seeks to ascertain a conclusion directly stemming from the available facts. Conversely, backward chaining operates by iteratively examining potential conclusions to identify a scenario wherein the existing facts substantiate any of these predetermined conclusions, essentially aligning the facts with an established conclusion through a reverse-engineering approach. This dichotomy facilitates diverse strategic applications in problem-solving and decision-making processes within various domains.

The expert system developed for this study employs a forward chaining methodology for logical inference. This procedural logic is exemplified through a series of interconnected rules, designed to sequentially process data from initial observations to deduce logical conclusions. The algorithmic function of this system is demonstrated by the following illustrative sequence of rules:

1. IF in the cardiovascular system fluctuations of blood pressure AND pain in the left half of the thorax

THEN it can cause heart rate disturbances.

2. IF there are heart rate irregularities

THEN in the respiratory system a feeling of shortness of breath OR choking AND shortness of breath.

3. IF the sensation of shortness of breath OR choking AND panting OR in the vestibular system dizziness

THEN is disorder of the autonomic nervous system.

4. IF disorders of the autonomic nervous system AND there are nervous redness on the skin of the face, neck, chest

THEN is a vegetative-vascular dystonia.

Let's say a patient has fluctuations of blood pressure and pain in the left side of the chest in the cardiovascular system, in this case, the conditional part TO of the first rule is fulfilled. The final part of the first rule is the condition (IF) of the second rule. The patient may feel shortness of breath or suffocation and panting in the respiratory system as it is fulfilled. The final part of the second rule represents a condition for the third rule i.e. when it is fulfilled, the patient is found to have disorders of the autonomic nervous system. And in the conclusion of the diagnosis at fulfilment of the conditional part of the 4th rule the patient is diagnosed with vegetative-vascular dystonia. In this case the expert system provides the neurologist with a treatment option for this disease.

Let's consider one of the operation scenarios of the system:

- The patient visits the clinic for a consultation or calls the clinic by phone for a consultation.
- The clinic administrator registers the patient (fills in the passport part of the outpatient card) and refers the patient to a neurologist.
- The neurologist listens to the patient's complaints and enters them into the computer.
- The neurologist examines the patient and enters objective clinical data into the computer.

- The neurologist sends the patient for additional examination (bacteriological analysis, X-ray, etc.) and enters the results into the computer.
- When requested by the expert system, the neurologist informs the expert system of the missing symptoms of the patient's illness.
- If necessary, the knowledge engineer edits the knowledge base in the direction of additional training.
- The expert system provides a diagnostic solution.
- The expert system, in case of a doctor's enquiry about the presumed diagnosis, explains and confirms the correctness of the diagnostic solution received by the system.

In conclusion, developing and deploying an expert system tailored for the diagnosis and treatment of neurological conditions, with a particular emphasis on vegetal-vascular dystonia, represents a significant stride towards enhancing clinical outcomes. By amalgamating a comprehensive knowledge base, sophisticated logical inference algorithms, and a user-friendly software interface, this system substantially elevates diagnostic accuracy and treatment efficacy for ailments such as headaches and vegetal-vascular dystonia. The integration of this technology into neurology practice not only augments the precision of medical diagnoses but also positively impacts the treatment protocols for patients, indicating a promising direction for future advancements in healthcare technology.