ITMO UNIVERSITY

Syntactic method

Natalia Khanzhina

Senior Researcher

Machine Learning Lab

nehanzhina@corp.ifmo.ru

Outline

- Structural approach
- Syntactic method

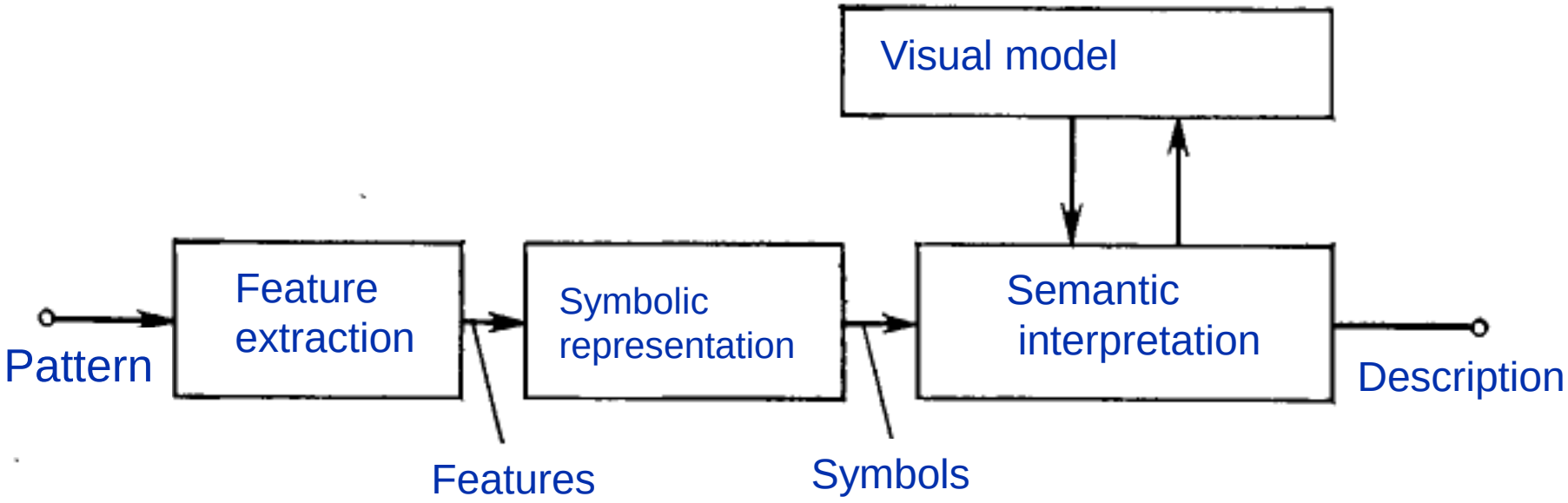
Scene recognition

- Structural approach is used for scene analysis and recognition, for image understanding systems
- Scene analysis requires a "verbal" description: “Body A is located above and to the right of the body B”

Models of image understanding systems

- Many models are proposed for image understanding systems.
- As a rule, they include the same set of blocks.
- Models differ in the organization of blocks, the nature of their management.

Models of image understanding systems



Symbols and features

- Examples of features : brightness of image elements, coordinates of contour points, texture parameters.
- Examples of symbols: segments, closed curves, planes.
- At the output of the semantic interpretation block, some desired description of the scene is obtained.

Visual model

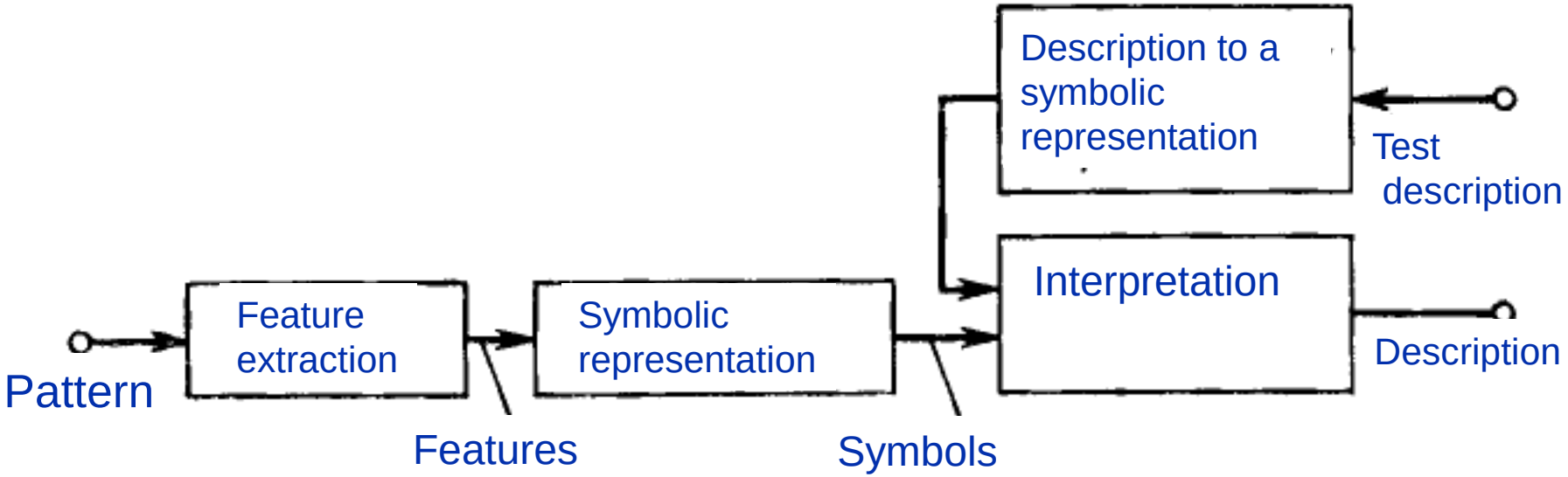
- Interpretation requires an a priori knowledge of the scene or class of scenes.
- This knowledge is included to visual models.
- They can be both very simple (object brighter than the background), and very complex (network relationship structure).

- The interpreting block analyzes all symbols and determines mutual spatial relations.
- And then compares it with the visual model.

Bottom-up structural analysis

- Such hierarchical “bottom-up" processing systems are applicable in limited areas where obtaining descriptions is simple and the range of change of input images is narrow.

Flow scheme of the “top-down" processing model



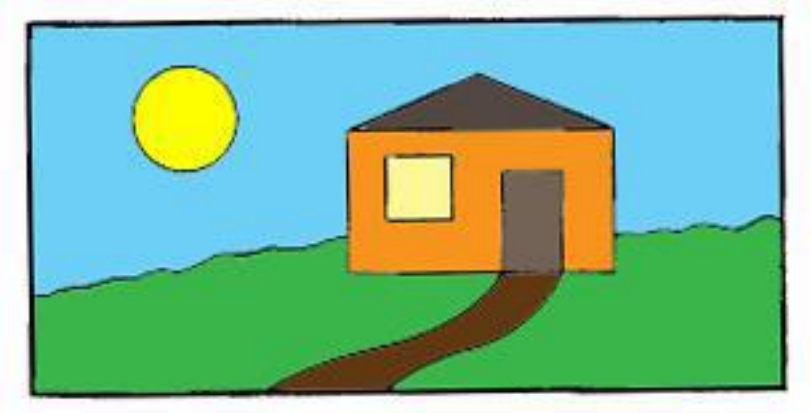
Top-down structural analysis

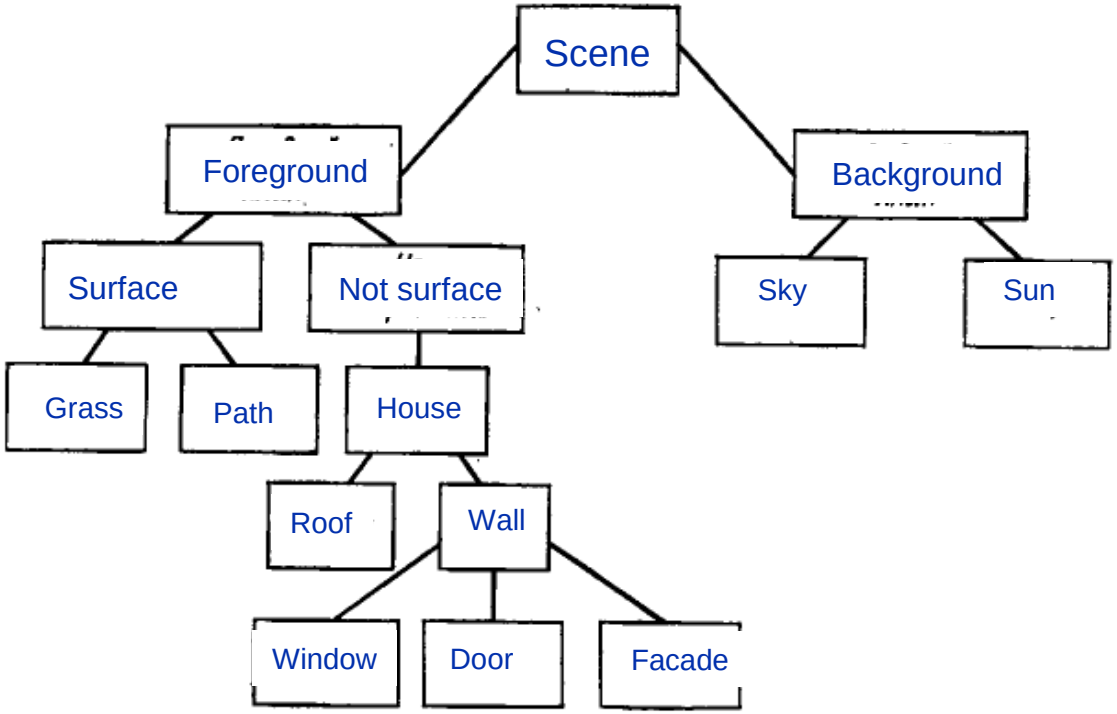
- Structural analysis is performed at the interpretation stage under the management of training examples.

- An example of such a system is a template matching.

- Such hierarchical systems are not adaptive.
- Most of the work done is useless.

- In the structural approach, objects are described not by a set of numeric features values, but by an object structure.
- A hierarchy involves describing complex objects using simpler subobjects.
- Those, in turn, can be described with the help of sub-objects of the next level, etc.




Scene
Foreground
Background
Surface
Not surface
Sky
Sun
Grass
Path
House
Roof
Wall
Window
Door
Facade

Features decomposition

- The success of the procedure is based on the detection of rather complex terminal macro symbols
- If the macro symbols can not be detected with sufficient accuracy, then the scene should be parsed with other simpler terminal symbols (ex. Line segments, spots).
- This leads to a rapid increase in the number of symbols.
- Therefore, a set of rewrite rules grows.

Syntactic methods of pattern recognition

- Methods of formal linguistics can be used for structural analysis of scenes, pattern recognition.

Formal definition of language:

- **Language** is a set of sentences composed according to some set of rules.
- **Sentence** is a collection of terminal symbols.
- **Alphabet** is a final set of symbols.
- **Grammar** is a collection of terminal and nonterminal symbols, rewrite rules, initial symbols.

- S = Boy_drew_picture
- T = {Boy, drew, picture, _} - the set of terminal symbols.
- N = {<Proposition>, <Noun Group>, <Verb Group>, <Noun>, <Verb>}
- Substitution rules:
- <Sentence> → <noun group> _ <verb group>

- <Group of the noun> → <Noun>
- <Verb group> → <Verb> _ <Noun group>
- <Noun> → Boy
- <Noun> → picture
- <Verb> → drew

When this approach is applied to image recognition, problems arise

- How to choose terminal symbols?
- How to develop the rules for rewriting?

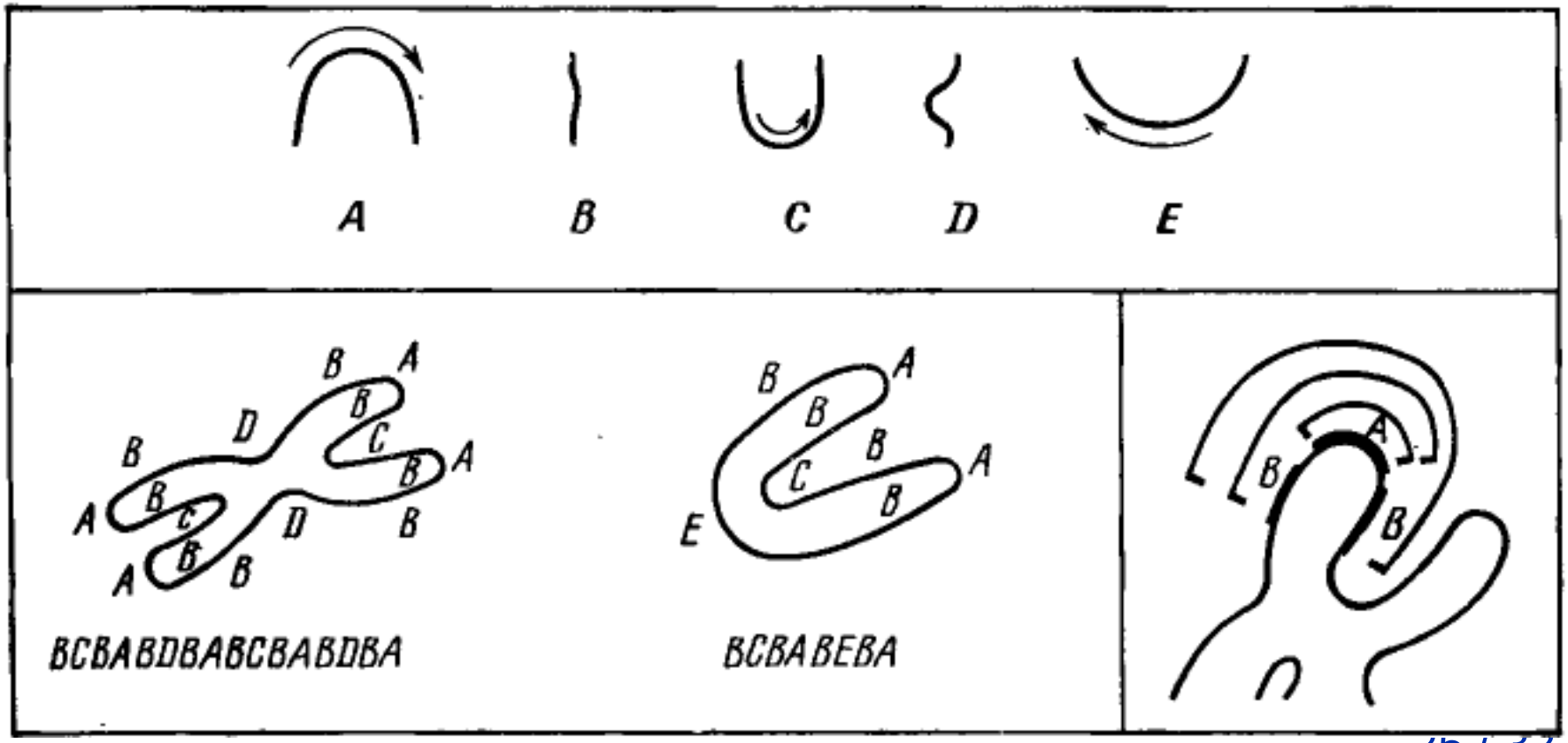
Syntactic approach

- This approach is based on the analogy between the structure of objects and the syntax of languages.
- It is acceptable when the simplest subobjects are isolated and recognized more easily than the image (object) as a whole.

- Rules for composing the simplest elements in describing an object are called the **grammar of the language of description of objects**.
- Simplest elements are primitives
- The recognition of an object consists in the recognition of primitive elements and the syntactic analysis (grammatical analysis) of the "sentence" describing the given object.

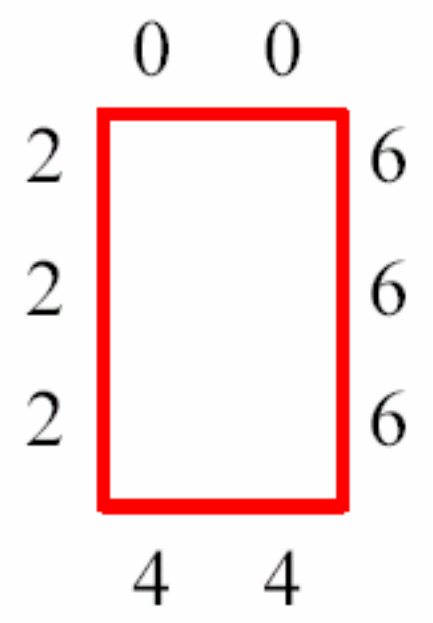
- The grammar of the language of description of objects is formed at the stage of training on the basis of the training sample.
- The theoretical basis of this approach is the theory of formal languages and the underlying generative grammars.

Classification of chromosomes

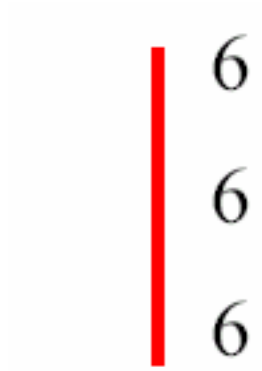


Digits classification

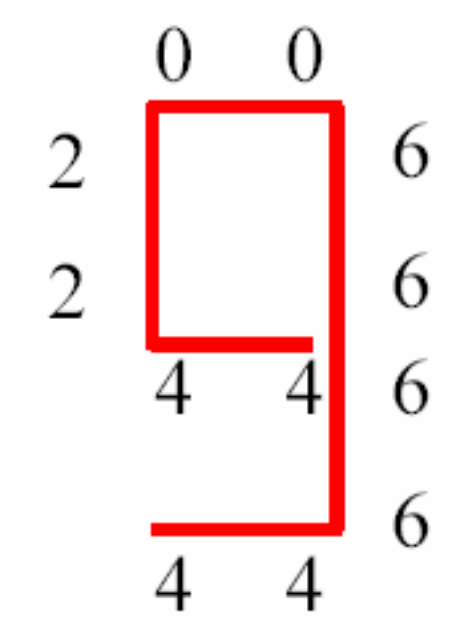
- T = {0, 2, 4, 6}
- N = {S, A, D, …I}
- P: S → 0A, A → 0B,
- B → 6C, C → 6D, D → 6E,
- E → 4F, F → 4G, G → 2H,
- H → 2I, I → 2



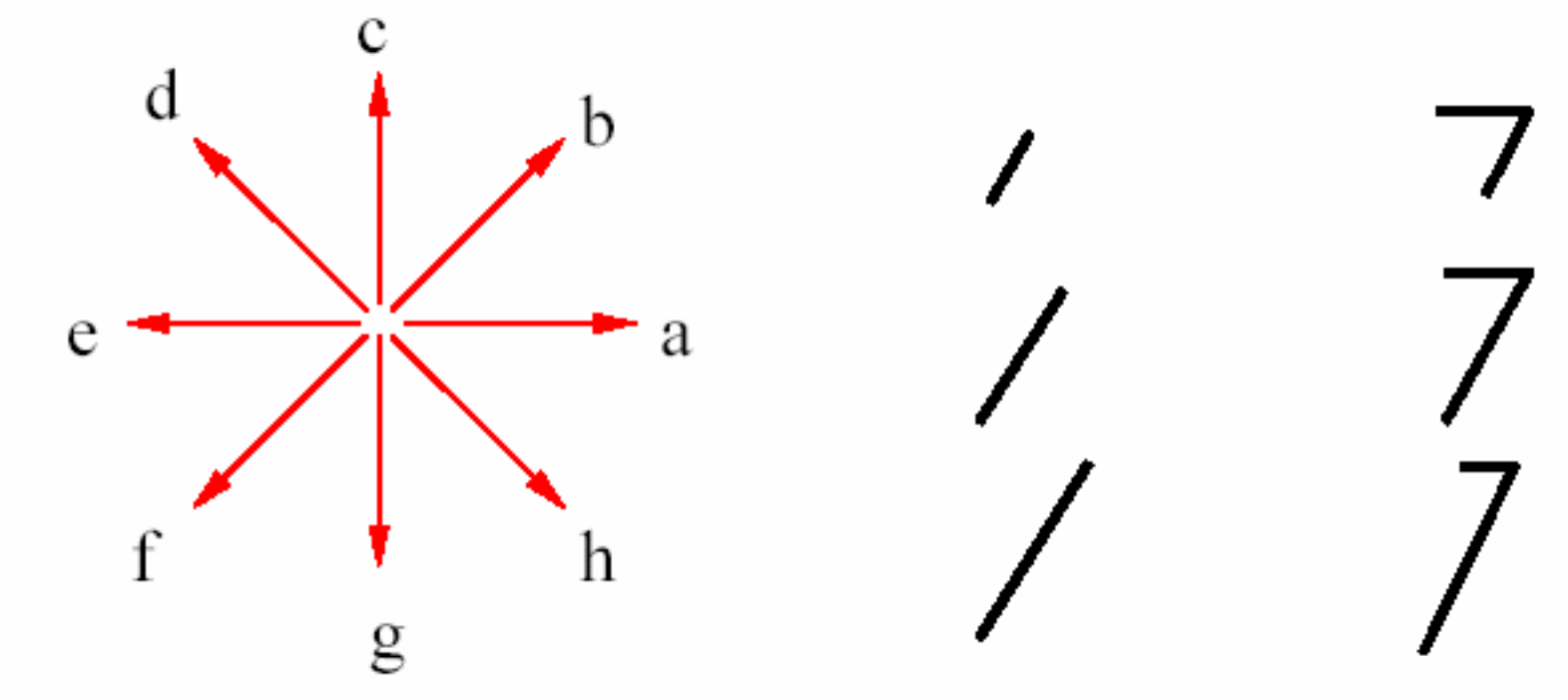
- T = {6}
- N = {S, A, B}
- P: S → 6A, A → 6B, B → 6



- T = {0, 2, 4, 6}
- N = {S, A, B, C…K}
- P : S → 4A, A → 4B, B → 2C,
- C → 2D, D → 0E, E → 0F,
- F → 6G, G → 6H, H → 6I,
- I → 6J, J → 4K, K → 4

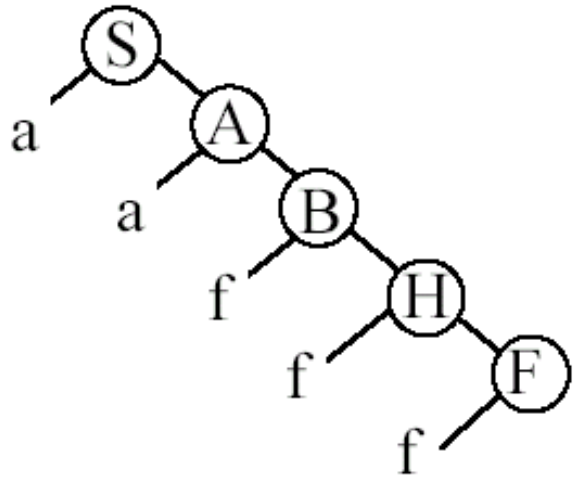


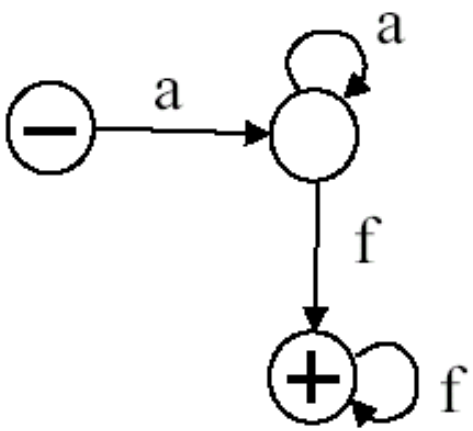
Grammar for «7»:

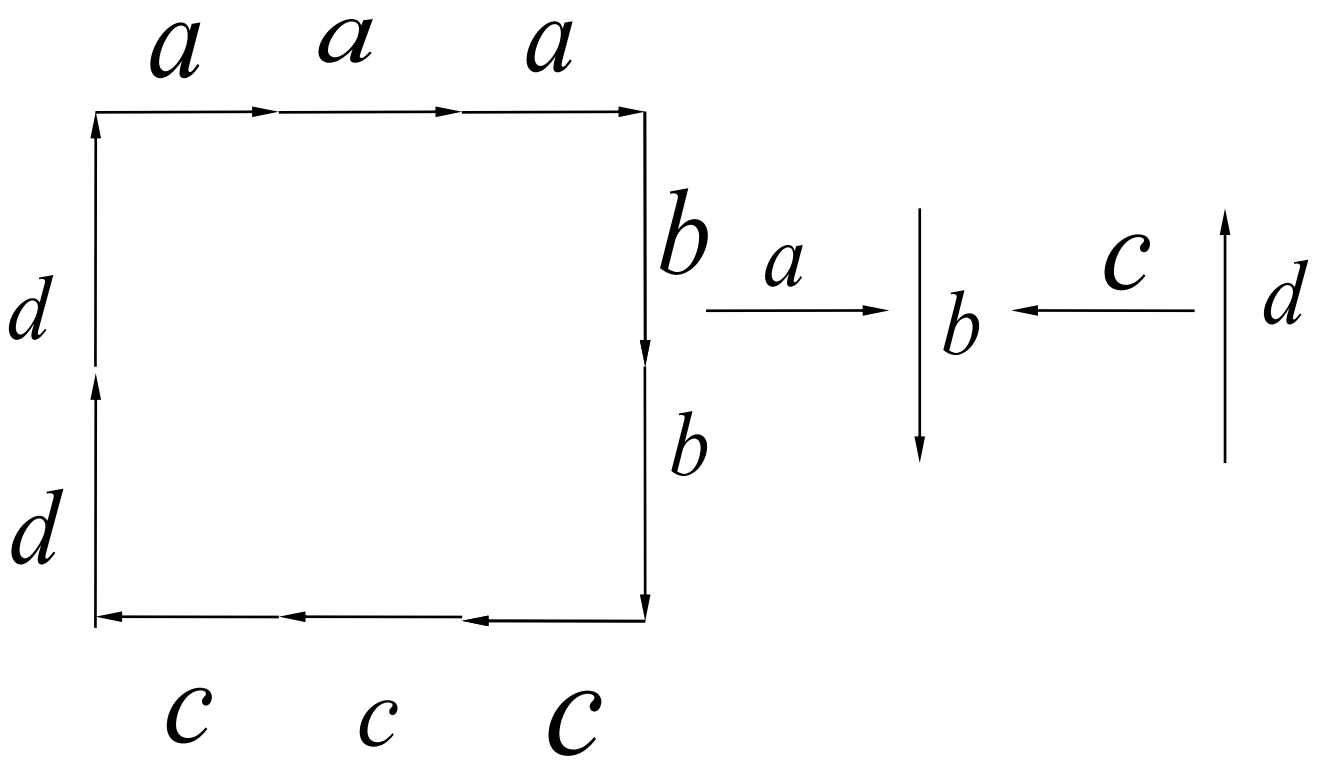


Grammar for «7»

- L = a+f+
- T = {a, f}
- N = {S, A, B,…}
- P: S → aA
- A → aB
- …
- D → fG
- …
- F → f







а б

$$a + a + a + b + b + c + c + c + d + d.$$

Conclusion

- The advantage of the syntactic approach is that if a large number of complex objects can be represented using a small set of primitives and grammatical rules (for example, the recognition of spoken words by the sequence of phonemes).