Network analysis of the novel The Master and Margarita by M. A. Bulgakov*

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The network analysis of the structure of social relationships in one of the most popular in Russian novels of the Soviet era by M. A. Bulgakov The Master and Margarita was carried out. The structure of the novel is complex, i.e., there is the novel within the novel. In our study, only relations between explicitly present and acting characters were taken into account; the mentioned characters as well as expected connections between characters were not taken into account. Based on the character interaction matrix, a graph was constructed, the vertices of which are the characters of the novel, while the edges correspond to connection between them. In our study, only the explicit interaction of the characters on the stage was considered. Interaction, i.e., bidirectional action, leads to the fact that, in our study, the social network is described by an ordinary, rather than directed graph. The largest connected component of the graph consists of 153 characters. Centralities, such as degree, betweenness, closeness, eigenvector, assortativity coefficient, were computed to characterize the network. The assortativity coefficient of the network under consideration equals to $-0.177$, which indicates artificiality of the network. The structure of communities in the network was analyzed using the Girvan—Newman algorithm. In addition to the obvious large communities — the characters from the Gospel part of the novel, the characters of the Moscow part of the novel, the characters of the other world — the algorithm also revealed a more subtle structure in the Moscow part of the novel: communities of writers, a hospital, and a theater. Using the analysis of centralities, a group of main characters has been detected. It turned out unexpectedly that — although the main character himself calls the novel within the novel The novel about Pilate — the central character of the Gospel part of the novel is Aphranius, rather than Pontius Pilate. Another central figures of the novel are Bezdomny, Koroviev, Behemoth, Berlioz, Zheldybin, Woland and Azazello. In the course of the study, we encountered a number of problems, the main is the difficulty of automating the study of social connections in novels.

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1. Introduction

In the last decade, the analysis of the structure of characters’ social networks has become actively applied to the analysis of religious \[14, 15\], mythological \[2, 12, 11, 13, 9, 7, 23, 27, 26, 28, 16\], and literary texts \[25, 6, 10, 8, 4\]. For example, the social network analysis of the biblical Moses \[14\], the social networks presented in four canonical Gospels and the Acts of the Apostles \[15\], the social networks of ancient Greek and Roman myths \[2\] and classical poems \[16\], the social connections of the Poem of Ossian \[27\], the social networks of Rabbinic literature \[28\], the social networks of Old English epic poems \[9\], the social networks of Russian bylinas \[23\], the social networks of Shakespeare’s plays \[25\], the social network of A Song of Ice and Fire \[4\]. Social network analysis has indicated authorial emphasis in the biblical Moses \[14\]. The analysis recovered the close relationship between the three synoptic Gospels, but The Gospel of John is recovered as an outgroup, reflecting its divergent nature \[15\]. The historicity of the events described in the Iliad and the Odyssey has been confirmed \[16\]. It is confirmed that Ossian is not the author of the works attributed to him \[27\]. Beowulf has been confirmed to be realistic with the exception of the protagonist, what is confirmed by independent historical studies \[9\]. Noticeable, the realistic structure of social connections in A Song of Ice and Fire, which, presumably, is one of the reasons for its high popularity \[4\]. Besides, computer analysis of the novel by M. A. Bulgakov Master and Margarita was also carried out \[20, 24\]. Authors have shown that the degree distributions of all analyzable networks are described by the distribution of q-type, also have calculated an entropy of the network. Since a complete network analysis of this novel has not been carried out in previous studies, the purpose of this study is precisely a complete network analysis.

The rest of the paper is constructed as follows. Section 2 describes some technical details of the network analysis of the novel The Master and Margarita by M. A. Bulgakov. Section 3 presents our main findings. Section 4 summarizes the main results.

2. Methods

A network analysis of the structure of social connections in one of the most popular novels in Soviet Russia by M.A. Bulgakov Master and Margarita was carried out. The structure of this piece of art is actually quite complex since it is the novel within the novel. Within the narrative of life in Moscow in the late 20’s and 30’s of the 20th century, the novel features
the story of Pontius Pilate. Both real people and otherworldly characters act in the novel. The complex structure of the novel and the combination of a quite realistic description of the relationships between the people of the Soviet era and a knowingly fictional otherworld allow us to expect an unusual and “multilayered” structure of social connections in the novel. Such a novel structure may be based on an unexpected structure of social connections. The highest popularity of the novel over several decades, presumably, can be associated (like A Song of Ice and Fire) with the realism of the described structure of social relationships. In our study, only connections between explicitly present and acting characters were taken into account, while the mentioned characters and expected connections were not taken into consideration. The requirement of the presence of a character on the stage automatically excludes from consideration the mentioned characters, for example, Caesar, Enanta, Niza’s husband, the former tenants of apartment 50. Explicit interaction excludes from consideration, for example, the Margarita and Latunsky pair, since Margarita’s trashing of Latunsky’s apartment is not a direct character interaction. Latunsky does not know Margarita, although after a conversation with Azazello in the Alexander Garden, Margarita knows Latunsky by sight.

Based on the character interaction matrix, a graph was constructed, the vertices of which are the characters of the novel, while the edges correspond to connections between them. Interaction, that is, bi-directional action, automatically assumes that the social network is described by a regular rather than an oriented graph. To analyze the resulting network, the R [21] tool with the igraph [3] library was used.

Degree (or valency) (deg V) is the number of edges incident to the node(vertex) V. In a network, a situation is possible, when nodes with a high degree (hubs, nodes with a number of links that greatly exceeds the average) are mainly associated with nodes with a high degree. In other words, hubs prefer to be associated with hubs. Such networks are called assortative. The opposite situation is also possible, viz., hubs are connected to other hubs through chains of nodes that have a small number of neighbors. Such networks are called disassortative [17].

Assortative mixing is a preference for a network’s nodes to attach to others that are similar in some way, in which nodes with high degrees are connected to nodes of the same high degree, while nodes with low degrees are connected to other low-connected nodes. To characterize this property, the assortativity coefficient is used. The assortativity coefficient r is the Pearson correlation coefficient of degree between pairs of linked nodes. Positive values of r indicate a correlation between nodes of similar degree, while negative values indicate relationships between nodes of different degree [9]. In general, r ∈ [−1; 1]. When r = 1, the network is said to have perfect
assortative mixing patterns, when $r = 0$, the network is non-assortative, while, at $r = -1$, the network is completely disassortative.

Networks related to real social phenomena are assortative. Networks associated, for example, with fictitious phenomena are more often disassortative [17].

In graph theory and network science, centrality assign numbers or rankings to nodes within a graph corresponding to their network position. Applications include identifying the most influential person(s) in a social network. The following types of centralities are used. Betweenness centrality is a measure of centrality in a graph based on shortest paths. For every pair of vertices in a connected graph, there exists at least one shortest path between the vertices such that either the number of edges that the path passes through (for unweighted graphs) or the sum of the weights of the edges (for weighted graphs) is minimized. The betweenness centrality for each vertex is the number of these shortest paths that pass through the vertex. More compactly the betweenness can be represented as [1]:

$$g(k) = \sum_{s \neq k \neq t} \sigma_{ij}(k) \sigma_{ij},$$  \hspace{1cm} (1)

where $\sigma_{ij}$ is equal to the total number of shortest paths from node $i$ to node $j$, and $\sigma_{ij}(k)$ is equal to the number of these paths passing through $k$.

In a connected graph, closeness centrality (or closeness) of a node is a measure of centrality in a network, calculated as the reciprocal of the sum of the length of the shortest paths between the node and all other nodes in the graph. Thus, the more central a node is, the closer it is to all other nodes [22].

$$C_i = \frac{1}{\sum_j d_{ji}},$$ \hspace{1cm} (2)

where $d_{ji}$ is equal to the distance between the nodes $i$ and $j$. In our study, normalized closeness centrality is used.

The degree of influence (eigenvector centrality) determines that the centrality of each node is the sum of the centrality values of the nodes to which it is connected. The eigenvector centrality is determined by the eigenvector associated with the largest eigenvalue of the adjacency matrix $A$. Formally, [19]

$$x_i = \frac{1}{\lambda} \sum_j A_{ij} x_j$$ \hspace{1cm} (3)

or, in matrix form,

$$Ax = \lambda x,$$ \hspace{1cm} (4)

where $x$ is the senior right eigenvector, while $\lambda$ is the greatest eigenvalue.
3. Results of the analysis

The gospel part of M. A. Bulgakov’s novel *Master and Margarita* has been analyzed. All characters involved in the gospel part can be divided into several groups: named speaking characters (e.g., Pilate), unnamed acting characters (e.g., legionaries), virtual characters, meaning the characters who do not appear on stage but are mentioned by other characters (e.g., Niza’s husband). Noticeable, this part of the novel contains only real characters, moreover, some of them are historical characters. The total number of characters is 39. Among them, 4 characters are virtual (Enanta, Niza’s husband, Tetrarch, Caesar). The social network of character interaction is shown in Fig. 1. The assortativity coefficient is \(-0.181\), which means that the network is disassortative. Thus, the social network of the gospel part of the novel can be treated as artificial.

Fig. 1. Character interaction network corresponding to gospel part of the novel. Vertex numbers correspond to the Table 1

Table 1 presents the main characteristics of the network: degree, betweenness centrality, closeness centrality, eigenvector centrality. The study showed that Aphranius has the greatest centrality, although there is no doubt that the central figure of the gospel part of Bulgakov’s novel is Pon-
Pilate.

Table 1: Centrality table (Yershalaim) Here, $g$ is the betweenness centrality \(1\), $C$ is the closeness centrality \(2\), and $x$ is the eigenvector centrality \(3\).

| Character                  | $\text{deg} V$ | $g$   | $C \times 10^3$ | $x \times 10^4$ |
|----------------------------|----------------|-------|-----------------|-----------------|
| 1. Pontius Pilate          | 19             | 98.292 | 0.0196         | 0.0567         |
| 2. Secretary               | 12             | 40.821 | 0.0172         | 0.0406         |
| 3. Legionnaire 1           | 10             | 6.3056 | 0.0161         | 0.0374         |
| 4. Legionnaire 2           | 10             | 6.3056 | 0.0161         | 0.0374         |
| 5. Yeshua Ha-Notsri        | 11             | 15.6794| 0.0169         | 0.0434         |
| 6. Mark Krysoboyi          | 17             | 47.5542| 0.0189         | 0.0663         |
| 7. Matthew Levi            | 7              | 44.3219| 0.0145         | 0.0173         |
| 8. Dismas                  | 10             | 3.3984 | 0.0152         | 0.0426         |
| 9. Gestas                  | 10             | 3.3984 | 0.0152         | 0.0426         |
| 10. Var-Rabban             | 7              | 2.1968 | 0.0154         | 0.0314         |
| 11. Judas of Kiriath       | 10             | 44.3381| 0.0169         | 0.0271         |
| 12. Aphrahius              | 20             | 160.7331| 0.0204        | 0.0576         |
| 13. Legion Commander       | 5              | 2.4111 | 0.0137         | 0.0172         |
| Legate                     |                |       |                 |                 |
| 14. Joseph Kaifa           | 6              | 9.7714 | 0.0152         | 0.0195         |
| 15. Member of Sanhedrin 1  | 3              | 0.3111 | 0.0123         | 0.0108         |
| 16. Member of Sanhedrin 2  | 3              | 0.3111 | 0.0123         | 0.0108         |
| 17. Temple Guard Chief     | 12             | 21.1344| 0.0172         | 0.0481         |
| 18. Soldier                | 4              | 2.8623 | 0.0132         | 0.0110         |
| 19. Commander of the ala   | 12             | 24.6159| 0.0152         | 0.0439         |
| 20. Executioner 1          | 12             | 7.6288 | 0.0164         | 0.0515         |
| 21. Executioner 2          | 12             | 7.6288 | 0.0164         | 0.0515         |
| 22. Executioner 3          | 9              | 1.1161 | 0.0152         | 0.0406         |
| 23. Executioner 4          | 9              | 1.1161 | 0.0152         | 0.0406         |
| 24. Executioner 5          | 9              | 1.1161 | 0.0152         | 0.0406         |
| 25. Executioner 6          | 9              | 1.1161 | 0.0152         | 0.0406         |
| 26. Mistress bakery        | 1              | 0     | 0.0098         | 0.0016         |
| 27. Cohort Commander       | 4              | 33    | 0.0137         | 0.0160         |
| 28. Ordinary               | 1              | 0     | 0.0094         | 0.0015         |
| 29. Servant 1              | 2              | 0     | 0.0143         | 0.0105         |
| 30. Servant 2              | 2              | 0     | 0.0143         | 0.0105         |
| 31. Niza                   | 3              | 33    | 0.0135         | 0.0079         |
| 32. Niza’s Maid            | 1              | 0     | 0.0093         | 0.0007         |
| 33. Judas Killer 1         | 3              | 0     | 0.0133         | 0.0086         |
| 34. Judas Killer 2         | 3              | 0     | 0.0133         | 0.0086         |
| 35. Tolmey                 | 2              | 1.5159| 0.0132         | 0.0069         |
Another cluster of Bulgakov’s work *The Master and Margarita* — *The Great Ball* was also analyzed. This cluster has 28 characters, which makes it the smallest in size. In this part of the novel, there are mostly otherworldly characters. The structure of the network resembles a “star”, the center of which is Margarita, who has the highest degree value. In addition, the characters Azazello, Koroviev, and Behemoth are highly connected vertices. The social network of interaction between the characters of *The Great Ball* is shown in the Fig. 2.

The assortativity coefficient (2) is $-0.638$, so the network is highly disassortative. Thus, the social network of this part of the novel seems to be artificial. Table 2 presents the main characteristics of the network: degree, betweenness centrality, closeness centrality, eigenvector centrality. As expected, Margarita, Azazello, Behemoth, Koroviev, Hella, and Natasha have the highest values of the main characteristics—the characters who take the most active part in the narrative.

| Character | $\text{deg} \ V$ | $g$ | $C \times 10^3$ | $x \times 10^4$ |
|-----------|-----------------|-----|----------------|----------------|
| 1. Margarita | 27              | 203 | 0.0370         | 0.0896         |
| 2. Rook    | 1               | 0   | 0.0189         | 0.0088         |
| 3. Azazello | 18              | 25  | 0.0278         | 0.0802         |

Fig. 2. Character interaction network corresponding to *The Great Ball*. Vertex numbers correspond to the Table 2.
Next, the Moscow part of Bulgakov’s novel *The Master and Margarita* was considered. There are 122 characters in this cluster. In this part of the novel, for the most part, there are both real and otherworldly characters. The high-connected vertices are the characters: Bezdomny, Koroviov, Behemoth, Berlioz, Zheldybin, Woland, and Azazello. The social network of interaction between the characters in the Moscow part of the novel is shown in Fig. 3.

The assortativity coefficient (2) is $-0.04$, hence, the network is non-assortative. Thus, the social network of this part of the novel seems to be artificial.
Fig. 3. Character interaction network corresponding to the Moscow part of the novel. Vertex numbers correspond to the Table 3.

Table 3: Centrality table (Moscow). Here, $g$ is the betweenness centrality [1], $C$ is the closeness centrality [2], and $x$ is the eigenvector centrality [3].

| Character            | deg $V$ | $g$   | $C \times 10^3$ | $x \times 10^4$ |
|----------------------|---------|-------|-----------------|-----------------|
| 1. Berlioz           | 17      | 386   | 3.26            | 0.224           |
| 2. Bezdomnyi         | 38      | 2450  | 3.83            | 0.0837          |
| 3. Woland            | 16      | 235   | 3.41            | 4.60            |
| 4. Beverage saleswoman | 2      | 0     | 2.56            | 26.3            |
| 5. Koroviev          | 30      | 1840  | 3.89            | 4.60            |
| 6. Woman 1           | 2       | 0     | 2.53            | 45.6            |
| 7. Woman 2           | 2       | 0     | 2.53            | 41.4            |
| 8. Azazello          | 16      | 322   | 3.44            | 4.60            |
| 9. Begemoth           | 25      | 944   | 3.71            | 4.60            |
| 10. Girl (from ap. 47) | 2     | 0     | 2.53            | 47.8            |
| 11. Woman (from ap.. 47) | 2     | 0     | 2.53            | 47.8            |
| 12. Amvrosy          | 13      | 0     | 2.76            | 1.33            |
## Continued table

| Character                   | deg $V$ | $g$    | $C \times 10^4$ | $x \times 10^4$ |
|-----------------------------|---------|--------|-----------------|-----------------|
| 13. Foka                    | 13      | 0      | 2.76            | 3.14            |
| 14. Beskudnikov             | 13      | 0      | 2.76            | 2.46            |
| 15. Dvubratskyi             | 13      | 0      | 2.76            | 3.05            |
| 16. Nepremenova             | 15      | 104    | 2.78            | 1.14            |
| 17. Zagrivova               | 13      | 0      | 2.76            | 1.46            |
| 18. Poprihin                | 13      | 0      | 2.76            | 1.46            |
| 19. Ababkov                 | 13      | 0      | 2.76            | 1.33            |
| 20. Gluharev                | 14      | 106    | 2.77            | 1.23            |
| 21. Deniskin                | 15      | 104    | 2.78            | 1.01            |
| 22. Zheldybin               | 17      | 399    | 2.84            | 0.231           |
| 23. Professor of Court. Med.| 3       | 0      | 2.06            | 55.5            |
| 24. Pathologist             | 3       | 0      | 2.06            | 57.7            |
| 25. Projector               | 3       | 0      | 2.06            | 55.5            |
| 26. Kvant                   | 13      | 0      | 2.76            | 1.25            |
| 27. Polumesyats             | 1       | 0      | 2.02            | 66.0            |
| 28. Zhukopov                | 1       | 0      | 1.52            | 402             |
| 29. Dragunskyi              | 3       | 0      | 2.03            | 30.8            |
| 30. Cherdakchi              | 3       | 0      | 2.03            | 31.5            |
| 31. Semeykina-Gull          | 0       | 0      | 0.00            | 9.73            |
| 32. Johann of Kronstadt     | 0       | 0      | 0.00            | 10.7            |
| 33. Vitya Kuftik            | 0       | 0      | 0.00            | 10.7            |
| 34. Pavianov                | 4       | 0      | 0.273           | 16.7            |
| 35. Bogohulskyi             | 4       | 0      | 0.273           | 12.6            |
| 36. Sladkyi                 | 4       | 0      | 0.273           | 10.3            |
| 37. Shpichkin               | 4       | 0      | 0.273           | 17.0            |
| 38. Adelphine Buzdyak       | 4       | 0      | 0.273           | 18.0            |
| 39. Archibald Archibaldovich| 10      | 417    | 3.15            | 6.85            |
| 40. Doorman                 | 5       | 0      | 2.60            | 31.5            |
| 41. Ryukhin                 | 8       | 127    | 2.69            | 28.4            |
| 42. Pantelei                | 5       | 0      | 2.60            | 31.5            |
| 43. Militiaman              | 5       | 0      | 2.60            | 33.0            |
| 44. Doctor                  | 7       | 53.5   | 2.66            | 30.8            |
| 45. Film Actress            | 2       | 106    | 1.92            | 355             |
| 46. Nurse                   | 3       | 210    | 2.57            | 40.7            |
| 47. Chauffeur (ch. 6)       | 1       | 0      | 1.97            | 155             |
| 48. Likhodeev               | 9       | 67.7   | 2.97            | 6.27            |
| 49. Grunya                  | 3       | 0      | 2.52            | 36.2            |
| 50. Rimskyi                 | 15      | 510    | 2.86            | 6.50            |
| 51. Nurse 1 (ch. 8)         | 4       | 0      | 2.59            | 36.4            |
| 52. Nurse 2 (ch. 8)         | 4       | 0      | 2.59            | 39.3            |
| Character                        | deg $V$ | $g$  | $C \times 10^4$ | $x \times 10^4$ |
|---------------------------------|---------|------|----------------|----------------|
| Nurse 3 (ch. 8)                 | 4       | 0    | 2.59           | 39.3           |
| Bosoyi                          | 8       | 423  | 2.96           | 34.7           |
| Pelageya Antonovna              | 3       | 0    | 2.12           | 176            |
| Citizen (mil-n) 1               | 3       | 0    | 2.12           | 208            |
| Citizen (mil-n) 2               | 3       | 0    | 2.12           | 178            |
| Kvassov                         | 2       | 6.40 | 2.31           | 82.0           |
| Varemukha                       | 14      | 208  | 2.77           | 6.28           |
| Woman (ch. 10)                  | 2       | 0    | 2.12           | 82.0           |
| Courier                         | 2       | 0    | 2.12           | 82.0           |
| Cashier                         | 2       | 0    | 2.12           | 82.0           |
| Hella                           | 12      | 36.0 | 2.90           | 5.50           |
| Praskovya Fedorovna             | 2       | 0    | 2.57           | 41.3           |
| Virtuoso Cyclist                | 2       | 0    | 0.137          | 12.6           |
| Full Blonde                     | 2       | 0    | 0.137          | 15.4           |
| 8-year-old boy                  | 2       | 0    | 0.137          | 16.7           |
| Courier                         | 1       | 0    | 2.06           | 99.8           |
| Bengalskyi                      | 3       | 0    | 2.62           | 39.3           |
| Brunette (ch. 12)               | 3       | 0    | 2.62           | 49.7           |
| Man backstage (ch. 12)          | 2       | 0    | 2.61           | 62.6           |
| Sempleyarov                     | 3       | 52.5 | 2.57           | 82.0           |
| Sempleyarov’s wife              | 3       | 52.5 | 2.57           | 82.0           |
| Sempleyarov’s relative          | 2       | 0    | 1.91           | 355            |
| Master                          | 13      | 370  | 3.29           | 5.03           |
| Margarita                       | 12      | 141  | 3.27           | 5.03           |
| Latushny                        | 3       | 0    | 2.29           | 82.0           |
| Ariman                          | 3       | 0    | 2.29           | 82.0           |
| Mstislav Lavrovich              | 3       | 0    | 2.29           | 82.0           |
| Lapshennikova                   | 2       | 0    | 2.62           | 39.3           |
| Aloysius                        | 7       | 1.50 | 2.78           | 18.0           |
| Kurierskyi                      | 1       | 0    | 2.06           | 99.2           |
| Prolezhnev                      | 0       | 0    | 0.00           | 10.7           |
| Lastochkin                      | 7       | 160  | 2.10           | 355            |
| Rimskyi’s wife                  | 2       | 30.4 | 2.14           | 85.3           |
| Cab Driver                      | 1       | 0    | 1.64           | 366            |
| Anna Richardovna                | 5       | 332  | 2.58           | 82.0           |
| Prokhor Petrovich               | 2       | 0    | 1.95           | 357            |
| Militiaman 1 (ch. 17)           | 3       | 0    | 1.95           | 355            |
| Militiaman 2 (ch. 17)           | 3       | 0    | 1.95           | 355            |
| Girl (ch. 17)                   | 6       | 341  | 2.71           | 69.6           |
| Doctor (ch. 17)                 | 2       | 0    | 1.98           | 355            |
Continued table

| Character                          | deg $V$ | $g$  | $C \times 10^3$ | $x \times 10^4$ |
|------------------------------------|---------|------|-----------------|-----------------|
| 93. Courier Karpov                | 2       | 0    | 1.98            | 355             |
| 94. Fanov                          | 3       | 0    | 2.62            | 82.0            |
| 95. Kosarchuk                      | 3       | 0    | 2.62            | 78.0            |
| 96. Poplavsky                      | 6       | 119  | 2.90            | 18.2            |
| 97. Pyatnazhko                     | 1       | 0    | 2.08            | 105             |
| 98. Sokov                          | 10      | 343  | 2.75            | 25.0            |
| 99. The woman with the green       | 1       | 0    | 2.01            | 132             |
| bag (ch. 18)                       |         |      |                 |                 |
| 100. Pharmacist                    | 1       | 0    | 2.01            | 125             |
| 101. Ksenia Nikitishna             | 2       | 0    | 2.02            | 86.6            |
| 102. Kuzmin                        | 4       | 116  | 2.40            | 82.0            |
| 103. Bure                          | 1       | 0    | 1.81            | 355             |
| 104. Natasha                       | 7       | 9.20 | 3.09            | 6.27            |
| 105. The Nameless Char. 1 (ch. 19) | 1       | 0    | 0.0683          | 12.6            |
| 106. The Nameless Char 2 (ch. 19)  | 1       | 0    | 0.0683          | 13.6            |
| 107. Man (ch. 19)                  | 1       | 0    | 2.27            | 82.0            |
| 108. Nikolai Ivanovich             | 8       | 8.20 | 2.72            | 6.85            |
| 109. Annushka                      | 2       | 1.60 | 2.52            | 74.8            |
| 110. Investigator                  | 8       | 162  | 2.89            | 18.4            |
| 111. Leading the investigation     | 4       | 0.290| 2.44            | 68.5            |
| 112. Doorman in the store          | 3       | 0    | 2.62            | 58.5            |
| 113. Store clerk                   | 1       | 0    | 1.52            | 496             |
| 114. Shopper in the store          | 2       | 106  | 1.92            | 363             |
| 115. A saleswoman in a store       | 3       | 0    | 2.62            | 57.7            |
| 116. Pavel Josephovich             | 4       | 0.340| 2.62            | 55.5            |
| 117. The old man in the store      | 2       | 210  | 2.58            | 82.0            |
| 118. Sofia Pavlova                  | 3       | 0    | 2.69            | 53.4            |
| 119. Petrankov-Sukhovey            | 3       | 52.5 | 2.23            | 85.3            |
| 120. Petrankov’s spouse            | 3       | 52.5 | 2.23            | 82.7            |
| 121. Boba Kandalupskui             | 2       | 0    | 1.71            | 363             |
| 122. Besdomnyi’s wife              | 1       | 0    | 2.52            | 47.8            |

The final part of the study was the consideration of the complete social network of the novel *The Master and Margarita* by M.A. Bulgakov. The complete network, which is a connected graph, contains 153 characters. The assortativity coefficient of the network under consideration equals to $-0.177$. As the clusters considered earlier, the network is disassortative. The most highly connected vertices are the following characters: Bezdomny, Woland and his entourage, Variety theater staff, Master, Margarita, Pontius Pilate, Aphranius. The social network of interaction between the characters of the
The structure of communities in the network was analyzed using igraph [3], viz., the Girvan—Newman algorithm [5] and modularity [18]. The last one gives a more complete understanding of clusters that can be interpreted easily. In addition to the obvious large communities — the characters from the Gospel part of the novel, the characters of the Moscow part of the novel, the characters of the other world — has been also revealed a more subtle structure in the Moscow part of the novel: communities of writers, a hospital, and a theater. The modularity of the network is 0.61.

4. Conclusion

The analysis of the structure of social connections of both the novel as a whole and its absolutely different parts: contemporary to the author Moscow, the gospel Yershalaim, the other world. Research has shown that 1) the high popularity of the novel is not associated with the structure of connections, close to real social networks; 2) in addition to the three
obvious clusters, there are other clusters in the Moscow part of the novel; 3) the central figure of the Gospel part of the novel is Aphranius; 4) we did not see that it is a novel about the devil. Woland is one of the central figures, but not the central one.

Table 4 shows the characters who take the most active part in Bulgakov’s novel. Table 4 evidenced that the title of the novel does not correspond to the most influential characters according to the network analysis. Neither Master nor Maragrita are the central characters according to any of the centralities. Despite to the correspondence by M. A. Bulgakov in which he said he was writing a novel about the devil, Woland is not a most influential characters according to any of the five centralities. Written by the Master *The novel about Pilate*, according to the network analysis, should be named as *The novel about Aphranius*. Thus, a character’s emotional significance is not necessarily related to his/her centrality on the network.

Table 4: Centrality table (The Master and Margarita). Here, $g$ is the betweenness centrality [1], $C$ is the closeness central-ity [2], and $x$ is the eigenvector centrality [3].

| Character      | deg $V$ | $g$   | $C \times 10^3$ | $x \times 10^4$ |
|----------------|--------|-------|-----------------|----------------|
| 1. Berlioz     | 17     | 544.4 | 0.003           | 0.418          |
| 2. Bezdonnyi   | 37     | 3837  | 0.003           | 0.718          |
| 3. Woland      | 20     | 2141  | 0.003           | 0.692          |
| 5. Koroviev    | 43     | 3203  | 0.003           | 1.000          |
| 8. Azazello    | 28     | 676.7 | 0.003           | 0.855          |
| 9. Begemoth    | 38     | 1810  | 0.003           | 0.969          |
| 22. Zheldybin  | 15     | 523.9 | 0.002           | 0.261          |
| 42. Rimskyi    | 15     | 717.3 | 0.002           | 0.392          |
| 51. Varemukha  | 14     | 380.4 | 0.002           | 0.411          |
| 55. Hella      | 13     | 64.50 | 0.003           | 0.536          |
| 64. Master     | 14     | 1747  | 0.003           | 0.489          |
| 65. Margarita  | 32     | 1398  | 0.003           | 0.807          |
| 129. Pontius Pilate | 16  | 98.29 | 0.002           | 0.099          |
| 132. Mark Krysoboyi | 11  | 91.30 | 0.002           | 0.015          |
| 138. Aphranius | 15     | 484.1 | 0.002           | 0.015          |

In the course of the study, we encountered a number of problems. First of all, is the results robust related to the random errors or imperfect methods? The second problem is the problem of virtual and double-natured characters. Do silent or inactive characters need to be considered when constructing a social network? Do double-natured characters (Berlioz, The Master,
Margarita, Pontius Pilate, Matthew Levi, et al.) need to be considered as two different entities (flesh and blood and ghost)?

The third problem is the problem of oriented graphs. Should the direction of connections be taken into account? In addition, can we consider knowledge rather than interactions as a social connection?

The fourth problem is the interpretation of centralities.

The fifth problem is the problem of automating the study of social relationships in works of fiction. If one supports the idea that a connection between two characters (vertices) is constructed if two characters are mentioned in the same sentence/paragraph, then the social network will not be constructed correctly. For example, in chapter number 5 of M. A. Bulgakov’s novel Master and Margarita, the members of the Board of MASSOLIT are obviously familiar with each other, but most characters are not mentioned side by side. It is only possible to build a faithful social network manually, which definitely complicates the work of analyzing the structure of the network.

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