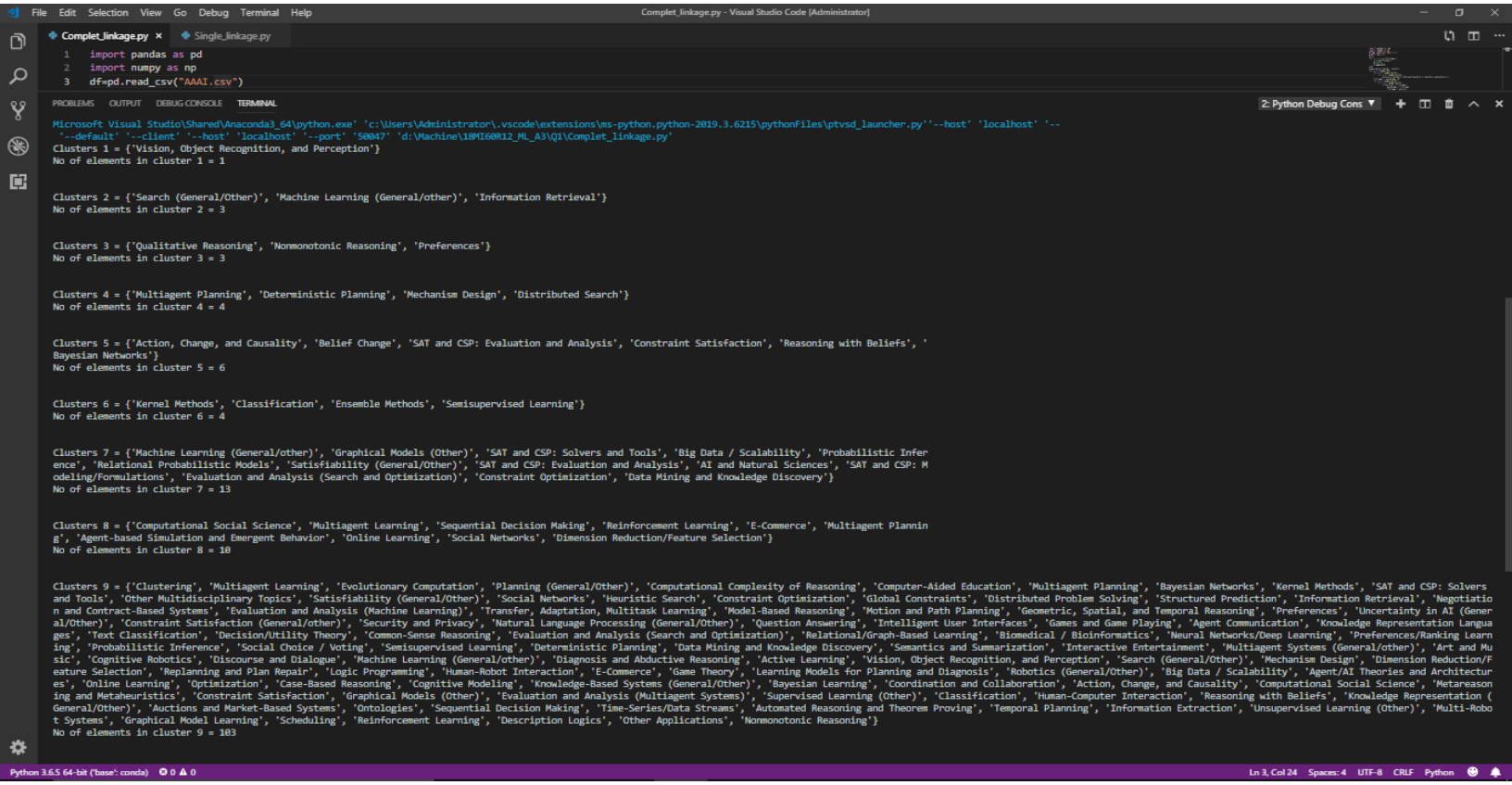
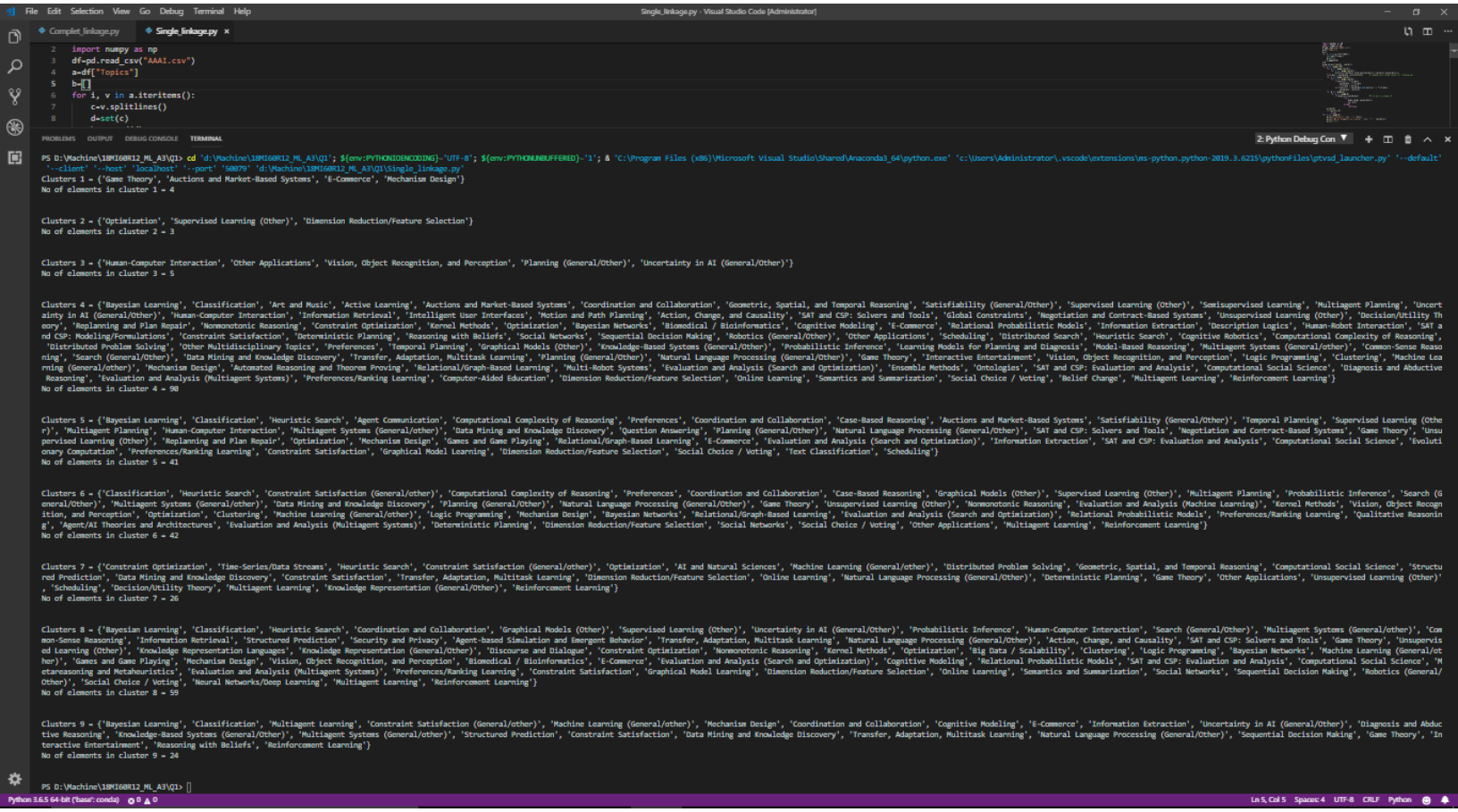
A) Here is the cluster generated by complete and single linkage and no of elements in them



```
import pandas as pd
import numpy as np
df=pd.read_csv("AAAI.csv")
```

```
Microsoft Visual Studio\Shared\Anaconda3_64\python.exe' 'c:\Users\Administrator\.vscode\extensions\ms-python.python-2019.3.6215\pythonFiles\ptvsd_launcher.py''--host' 'localhost' '--
 '--default' '--client' '--host' 'localhost' '--port' '50047' 'd:\Machine\18MI60R12_ML_A3\Q1\Complet_linkage.py'
Clusters 1 = {'Vision, Object Recognition, and Perception'}
No of elements in cluster 1 = 1


Clusters 2 = {'Search (General/Other)', 'Machine Learning (General/other)', 'Information Retrieval'}
No of elements in cluster 2 = 3


Clusters 3 = {'Qualitative Reasoning', 'Nonmonotonic Reasoning', 'Preferences'}
No of elements in cluster 3 = 3


Clusters 4 = {'Multiagent Planning', 'Deterministic Planning', 'Mechanism Design', 'Distributed Search'}
No of elements in cluster 4 = 4


Clusters 5 = {'Action, Change, and Causality', 'Belief Change', 'SAT and CSP: Evaluation and Analysis', 'Constraint Satisfaction', 'Reasoning with Beliefs', '
Bayesian Networks'}
No of elements in cluster 5 = 6


Clusters 6 = {'Kernel Methods', 'Classification', 'Ensemble Methods', 'Semisupervised Learning'}
No of elements in cluster 6 = 4


Clusters 7 = {'Machine Learning (General/other)', 'Graphical Models (Other)', 'SAT and CSP: Solvers and Tools', 'Big Data / Scalability', 'Probabilistic Infer
ence', 'Relational Probabilistic Models', 'Satisfiability (General/Other)', 'SAT and CSP: Evaluation and Analysis', 'AI and Natural Sciences', 'SAT and CSP: M
odeling/Formulations', 'Evaluation and Analysis (Search and Optimization)', 'Constraint Optimization', 'Data Mining and Knowledge Discovery'}
No of elements in cluster 7 = 13


Clusters 8 = {'Computational Social Science', 'Multiagent Learning', 'Sequential Decision Making', 'Reinforcement Learning', 'E-Commerce', 'Multiagent Plannin
g', 'Agent-based Simulation and Emergent Behavior', 'Online Learning', 'Social Networks', 'Dimension Reduction/Feature Selection'}
No of elements in cluster 8 = 10


Clusters 9 = {'Clustering', 'Multiagent Learning', 'Evolutionary Computation', 'Planning (General/Other)', 'Computational Complexity of Reasoning', 'Computer-Aided Education', 'Multiagent Planning', 'Bayesian Networks', 'Kernel Methods', 'SAT and CSP: Solvers
and Tools', 'Other Multidisciplinary Topics', 'Satisfiability (General/Other)', 'Social Networks', 'Heuristic Search', 'Constraint Optimization', 'Global Constraints', 'Distributed Problem Solving', 'Structured Prediction', 'Information Retrieval', 'Negotiatio
n and Contract-Based Systems', 'Evaluation and Analysis (Machine Learning)', 'Transfer, Adaptation, Multitask Learning', 'Model-Based Reasoning', 'Motion and Path Planning', 'Geometric, Spatial, and Temporal Reasoning', 'Preferences', 'Uncertainty in AI (Gener
al/Other)', 'Constraint Satisfaction (General/other)', 'Security and Privacy', 'Natural Language Processing (General/Other)', 'Question Answering', 'Intelligent User Interfaces', 'Games and Game Playing', 'Agent Communication', 'Knowledge Representation Langua
ges', 'Text Classification', 'Decision/Utility Theory', 'Common-Sense Reasoning', 'Evaluation and Analysis (Search and Optimization)', 'Relational/Graph-Based Learning', 'Biomedical / Bioinformatics', 'Neural Networks/Deep Learning', 'Preferences/Ranking Learn
ing', 'Probabilistic Inference', 'Social Choice / Voting', 'Semisupervised Learning', 'Deterministic Planning', 'Data Mining and Knowledge Discovery', 'Semantics and Summarization', 'Interactive Entertainment', 'Multiagent Systems (General/other)', 'Art and Mu
sic', 'Cognitive Robotics', 'Discourse and Dialogue', 'Machine Learning (General/other)', 'Diagnosis and Abductive Reasoning', 'Active Learning', 'Vision, Object Recognition, and Perception', 'Search (General/Other)', 'Mechanism Design', 'Dimension Reduction/F
eature Selection', 'Replanning and Plan Repair', 'Logic Programming', 'Human-Robot Interaction', 'E-Commerce', 'Game Theory', 'Learning Models for Planning and Diagnosis', 'Robotics (General/Other)', 'Big Data / Scalability', 'Agent/AI Theories and Architectur
es', 'Online Learning', 'Optimization', 'Case-Based Reasoning', 'Cognitive Modeling', 'Knowledge-Based Systems (General/Other)', 'Bayesian Learning', 'Coordination and Collaboration', 'Action, Change, and Causality', 'Computational Social Science', 'Metareason
ing and Metaheuristics', 'Constraint Satisfaction', 'Graphical Models (Other)', 'Evaluation and Analysis (Multiagent Systems)', 'Supervised Learning (Other)', 'Classification', 'Human-Computer Interaction', 'Reasoning with Beliefs', 'Knowledge Representation (
General/Other)', 'Auctions and Market-Based Systems', 'Ontologies', 'Sequential Decision Making', 'Time-Series/Data Streams', 'Automated Reasoning and Theorem Proving', 'Temporal Planning', 'Information Extraction', 'Unsupervised Learning (Other)', 'Multi-Robo
t Systems', 'Graphical Model Learning', 'Scheduling', 'Reinforcement Learning', 'Description Logics', 'Other Applications', 'Nonmonotonic Reasoning'}
No of elements in cluster 9 = 103
```



```
import numpy as np
df=pd.read_csv("AAAI.csv")
a=df["Topics"]
b=[]
for i, v in a.iteritems():
    c=v.splitlines()
    d=set(c)
```

```
PS D:\Machine\18MI60R12_ML_A3\Q1> cd 'd:\Machine\18MI60R12_ML_A3\Q1'; ${env:PYTHONIOENCODING}='UTF-8'; ${env:PYTHONUNBUFFERED}='1'; & 'C:\Program Files (x86)\Microsoft Visual Studio\Shared\Anaconda3_64\python.exe' 'c:\Users\Administrator\.vscode\extensions\ms-python.python-2019.3.6215\pythonFiles\ptvsd_launcher.py' '--default'
 '--client' '--host' 'localhost' '--port' '50079' 'd:\Machine\18MI60R12_ML_A3\Q1\Single_linkage.py'
Clusters 1 = {'Game Theory', 'Auctions and Market-Based Systems', 'E-Commerce', 'Mechanism Design'}
No of elements in cluster 1 = 4


Clusters 2 = {'Optimization', 'Supervised Learning (Other)', 'Dimension Reduction/Feature Selection'}
No of elements in cluster 2 = 3


Clusters 3 = {'Human-Computer Interaction', 'Other Applications', 'Vision, Object Recognition, and Perception', 'Planning (General/Other)', 'Uncertainty in AI (General/Other)'}
No of elements in cluster 3 = 5


Clusters 4 = {'Bayesian Learning', 'Classification', 'Art and Music', 'Active Learning', 'Auctions and Market-Based Systems', 'Coordination and Collaboration', 'Geometric, Spatial, and Temporal Reasoning', 'Satisfiability (General/Other)', 'Supervised Learning (Other)', 'Semisupervised Learning', 'Multiagent Planning', 'Uncert
ainty in AI (General/Other)', 'Human-Computer Interaction', 'Information Retrieval', 'Intelligent User Interfaces', 'Motion and Path Planning', 'Action, Change, and Causality', 'SAT and CSP: Solvers and Tools', 'Global Constraints', 'Negotiation and Contract-Based Systems', 'Unsupervised Learning (Other)', 'Decision/Utility Th
eory', 'Replanning and Plan Repair', 'Nonmonotonic Reasoning', 'Constraint Optimization', 'Kernel Methods', 'Optimization', 'Bayesian Networks', 'Biomedical / Bioinformatics', 'Cognitive Modeling', 'E-Commerce', 'Relational Probabilistic Models', 'Information Extraction', 'Description Logics', 'Human-Robot Interaction', 'SAT a
nd CSP: Modeling/Formulations', 'Constraint Satisfaction', 'Deterministic Planning', 'Reasoning with Beliefs', 'Social Networks', 'Sequential Decision Making', 'Robotics (General/Other)', 'Other Applications', 'Scheduling', 'Distributed Search', 'Heuristic Search', 'Cognitive Robotics', 'Computational Complexity of Reasoning',
 'Distributed Problem Solving', 'Other Multidisciplinary Topics', 'Preferences', 'Temporal Planning', 'Graphical Models (Other)', 'Knowledge-Based Systems (General/Other)', 'Probabilistic Inference', 'Learning Models for Planning and Diagnosis', 'Model-Based Reasoning', 'Multiagent Systems (General/other)', 'Common-Sense Reaso
ning', 'Search (General/Other)', 'Data Mining and Knowledge Discovery', 'Transfer, Adaptation, Multitask Learning', 'Planning (General/Other)', 'Natural Language Processing (General/Other)', 'Game Theory', 'Interactive Entertainment', 'Vision, Object Recognition, and Perception', 'Logic Programming', 'Clustering', 'Machine Lea
rning (General/other)', 'Mechanism Design', 'Automated Reasoning and Theorem Proving', 'Relational/Graph-Based Learning', 'Multi-Robot Systems', 'Evaluation and Analysis (Search and Optimization)', 'Ensemble Methods', 'Ontologies', 'SAT and CSP: Evaluation and Analysis', 'Computational Social Science', 'Diagnosis and Abductive
 Reasoning', 'Evaluation and Analysis (Multiagent Systems)', 'Preferences/Ranking Learning', 'Computer-Aided Education', 'Dimension Reduction/Feature Selection', 'Online Learning', 'Semantics and Summarization', 'Social Choice / Voting', 'Belief Change', 'Multiagent Learning', 'Reinforcement Learning'}
No of elements in cluster 4 = 98


Clusters 5 = {'Bayesian Learning', 'Classification', 'Heuristic Search', 'Agent Communication', 'Computational Complexity of Reasoning', 'Preferences', 'Coordination and Collaboration', 'Case-Based Reasoning', 'Auctions and Market-Based Systems', 'Satisfiability (General/Other)', 'Temporal Planning', 'Supervised Learning (Othe
r)', 'Multiagent Planning', 'Human-Computer Interaction', 'Multiagent Systems (General/other)', 'Data Mining and Knowledge Discovery', 'Question Answering', 'Planning (General/Other)', 'Natural Language Processing (General/Other)', 'SAT and CSP: Solvers and Tools', 'Negotiation and Contract-Based Systems', 'Game Theory', 'Unsu
pervised Learning (Other)', 'Replanning and Plan Repair', 'Optimization', 'Mechanism Design', 'Games and Game Playing', 'Relational/Graph-Based Learning', 'E-Commerce', 'Evaluation and Analysis (Search and Optimization)', 'Information Extraction', 'SAT and CSP: Evaluation and Analysis', 'Computational Social Science', 'Evoluti
onary Computation', 'Preferences/Ranking Learning', 'Constraint Satisfaction', 'Graphical Model Learning', 'Dimension Reduction/Feature Selection', 'Social Choice / Voting', 'Text Classification', 'Scheduling'}
No of elements in cluster 5 = 41


Clusters 6 = {'Classification', 'Heuristic Search', 'Constraint Satisfaction (General/other)', 'Computational Complexity of Reasoning', 'Preferences', 'Coordination and Collaboration', 'Case-Based Reasoning', 'Graphical Models (Other)', 'Supervised Learning (Other)', 'Multiagent Planning', 'Probabilistic Inference', 'Search (G
eneral/Other)', 'Multiagent Systems (General/other)', 'Data Mining and Knowledge Discovery', 'Planning (General/Other)', 'Natural Language Processing (General/Other)', 'Game Theory', 'Unsupervised Learning (Other)', 'Nonmonotonic Reasoning', 'Evaluation and Analysis (Machine Learning)', 'Kernel Methods', 'Vision, Object Recogn
ition, and Perception', 'Optimization', 'Clustering', 'Machine Learning (General/other)', 'Logic Programming', 'Mechanism Design', 'Bayesian Networks', 'Relational/Graph-Based Learning', 'Evaluation and Analysis (Search and Optimization)', 'Relational Probabilistic Models', 'Preferences/Ranking Learning', 'Qualitative Reasonin
g', 'Agent/AI Theories and Architectures', 'Evaluation and Analysis (Multiagent Systems)', 'Deterministic Planning', 'Dimension Reduction/Feature Selection', 'Social Networks', 'Social Choice / Voting', 'Other Applications', 'Multiagent Learning', 'Reinforcement Learning'}
No of elements in cluster 6 = 42


Clusters 7 = {'Constraint Optimization', 'Time-Series/Data Streams', 'Heuristic Search', 'Constraint Satisfaction (General/other)', 'Optimization', 'AI and Natural Sciences', 'Machine Learning (General/other)', 'Distributed Problem Solving', 'Geometric, Spatial, and Temporal Reasoning', 'Computational Social Science', 'Structu
red Prediction', 'Data Mining and Knowledge Discovery', 'Constraint Satisfaction', 'Transfer, Adaptation, Multitask Learning', 'Dimension Reduction/Feature Selection', 'Online Learning', 'Natural Language Processing (General/Other)', 'Deterministic Planning', 'Game Theory', 'Other Applications', 'Unsupervised Learning (Other)
', 'Scheduling', 'Decision/Utility Theory', 'Multiagent Learning', 'Knowledge Representation (General/Other)', 'Reinforcement Learning'}
No of elements in cluster 7 = 26


Clusters 8 = {'Bayesian Learning', 'Classification', 'Heuristic Search', 'Coordination and Collaboration', 'Graphical Models (Other)', 'Supervised Learning (Other)', 'Uncertainty in AI (General/Other)', 'Probabilistic Inference', 'Human-Computer Interaction', 'Search (General/Other)', 'Multiagent Systems (General/other)', 'Com
mon-Sense Reasoning', 'Information Retrieval', 'Structured Prediction', 'Security and Privacy', 'Agent-based Simulation and Emergent Behavior', 'Transfer, Adaptation, Multitask Learning', 'Natural Language Processing (General/Other)', 'Action, Change, and Causality', 'SAT and CSP: Solvers and Tools', 'Game Theory', 'Unsupervis
ed Learning (Other)', 'Knowledge Representation Languages', 'Knowledge Representation (General/Other)', 'Discourse and Dialogue', 'Constraint Optimization', 'Nonmonotonic Reasoning', 'Kernel Methods', 'Optimization', 'Big Data / Scalability', 'Clustering', 'Logic Programming', 'Bayesian Networks', 'Machine Learning (General/ot
her)', 'Games and Game Playing', 'Mechanism Design', 'Vision, Object Recognition, and Perception', 'Biomedical / Bioinformatics', 'E-Commerce', 'Evaluation and Analysis (Search and Optimization)', 'Cognitive Modeling', 'Relational Probabilistic Models', 'SAT and CSP: Evaluation and Analysis', 'Computational Social Science', 'M
etareasoning and Metaheuristics', 'Evaluation and Analysis (Multiagent Systems)', 'Preferences/Ranking Learning', 'Constraint Satisfaction', 'Graphical Model Learning', 'Dimension Reduction/Feature Selection', 'Online Learning', 'Semantics and Summarization', 'Social Networks', 'Sequential Decision Making', 'Robotics (General/
Other)', 'Social Choice / Voting', 'Neural Networks/Deep Learning', 'Multiagent Learning', 'Reinforcement Learning'}
No of elements in cluster 8 = 59


Clusters 9 = {'Bayesian Learning', 'Classification', 'Multiagent Learning', 'Constraint Satisfaction (General/other)', 'Machine Learning (General/other)', 'Mechanism Design', 'Coordination and Collaboration', 'Cognitive Modeling', 'E-Commerce', 'Information Extraction', 'Uncertainty in AI (General/Other)', 'Diagnosis and Abduc
tive Reasoning', 'Knowledge-Based Systems (General/Other)', 'Multiagent Systems (General/other)', 'Structured Prediction', 'Constraint Satisfaction', 'Data Mining and Knowledge Discovery', 'Transfer, Adaptation, Multitask Learning', 'Natural Language Processing (General/Other)', 'Sequential Decision Making', 'Game Theory', 'In
teractive Entertainment', 'Reasoning with Beliefs', 'Reinforcement Learning'}
No of elements in cluster 9 = 24


PS D:\Machine\18MI60R12_ML_A3\Q1>
```

B) NMI values of the three clustering are as follows

For Complete Linkage, NMI= 0.102

For Single Linkage, NMI= 0.0896

For Graph Clustering, NMI= underdetermined (as computing power requirement was large and I could not get the output)

C) Threshold value taken=0.002
This value is taken by observing the values of centralities.