МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ ТЕХНІЧНИЙ УНІВЕРСИТЕТ УКРАЇНИ
„КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ”
НАВЧАЛЬНО-НАУКОВИЙ ІНСТИТУТ ПРИКЛАДНОГО СИСТЕМНОГО АНАЛІЗУ

Лабораторна робота №1

з курсу : «Байєсівський аналіз даних в наукових дослідженнях»

Виконав:
аспірант 2 курсу ННІПСА
Групи КН-31ф
Кузнєцов Олексій Андрійович

Київ – 2024

Мета роботи: Ознайомлення з основами теорії байєсівських мереж. Формула Байєса для обчислення значень ймовірностей.

Завдання: Напишіть комп'ютерну програму, що повинна:

– обчислювати значень ймовірностей станів вершин

– обчислювати значення спільної ймовірності мережі Байєса

Мова програмування будь-яка.

Програма може не будувати графічну структуру мережі Байєса.

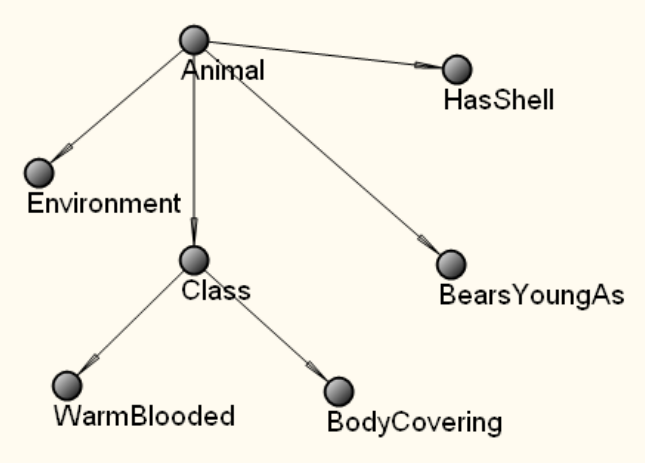
Головна мета – коректно запрограмовані формули для обчислення значень ймовірностей.

На вхід програмі подаються значення умовних ймовірностей вершин.

Постановка завдання:

Мережа Animals

Структура мережі.



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Таблиці умовних ймовірностей

Animal

Monkey	***Penguin***	***Platypus***	***Robin***	***Turtle***
0,2	0,2	0,2	0,2	0,2

Environment

Animal	***Air***	***Land***	***Water***
Monkey	0	1	0

Penguin	0	0,5	0,5
Platypus	0	0	1
Robin	0,5	0,5	0
Turtle	0	0,5	0,5

HasShell

Animal	***True***	***False***
Monkey	0	1
Penguin	0	1
Platypus	0	1
Robin	0	1
Turtle	1	0

BearsYoungAs

Animal	***Live***	***Eggs***
Monkey	1	0
Penguin	0	1
Platypus	0	1
Robin	0	1
Turtle	0	1

Class

Animal	***Bird***	***Mammal***	***Reptile***
Monkey	0	1	0
Penguin	1	0	0
Platypus	0	1	0
Robin	1	0	0
Turtle	0	0	1

WarmBlooded

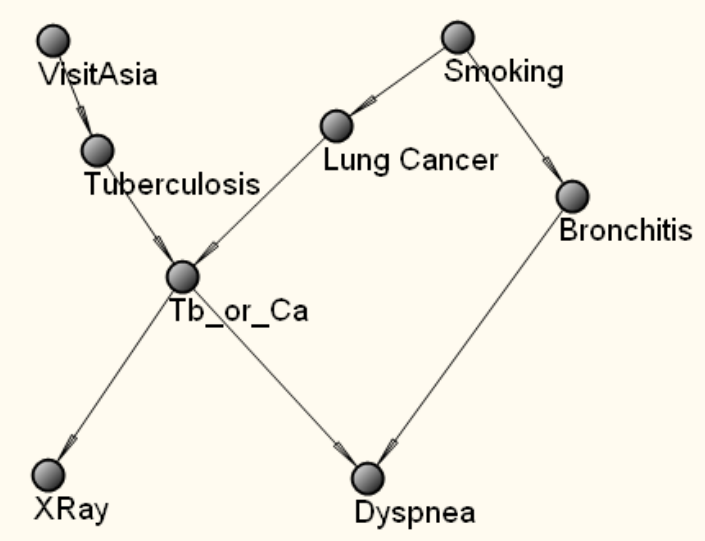
Class	*True*	*False*
Bird	1	0
Mammal	1	0
Reptile	0	1

BodyCovering

Class	*Fur*	*Feathers*	*Scales*
Bird	0	1	0
Mammal	1	0	0
Reptile	0	0	1

Мережа Asia

Структура мережі.



Таблиці умовних ймовірностей

VisitAsia

Visit	*NoVisit*
0,01	0,99

Smoking

Smoking	*NoSmoking*
0,5	0,5

Tuberculosis

VisitAsia	*Present*	*Absent*
Visit	0,05	0,95
NoVisit	0,01	0,99

Lung Cancer

Smoking	*present*	*Absent*
Smoking	0,1	0,9
NoSmoking	0,01	0,99

Tb_or_Ca

Tuberculosis	Lung Cancer	*True*	*False*
Present	***present***	1	0
Present	***Absent***	1	0
Absent	***present***	1	0
Absent	***Absent***	0	1

XRay

Tb_or_Ca	*abnormal*	*normal*
True	0,98	0,02
False	0,05	0,95

Bronchitis

Smoking	*Present*	*Absent*
Smoking	0,6	0,4
NoSmoking	0,3	0,7

Dyspnea

Tb_or_Ca	Bronchitis	*True*	*False*
True	***Present***	0,9	0,1
True	***Absent***	0,7	0,3
False	***Present***	0,8	0,2
False	***Absent***	0,1	0,9

Результати роботи програми:

Мережа Animals

Significant Joint Probabilities with State Descriptions:

State: Animal: Monkey, Environment: Land, HasShell: False, BearsYoungAs: Live, Class: Mammal, WarmBlooded: True, BodyCovering: Fur, Probability: 0.2000000000

State: Animal: Penguin, Environment: Land, HasShell: False, BearsYoungAs: Eggs, Class: Bird, WarmBlooded: True, BodyCovering: Feathers, Probability: 0.1000000000

State: Animal: Penguin, Environment: Water, HasShell: False, BearsYoungAs: Eggs, Class: Bird, WarmBlooded: True, BodyCovering: Feathers, Probability: 0.1000000000

State: Animal: Platypus, Environment: Water, HasShell: False, BearsYoungAs: Eggs, Class: Mammal, WarmBlooded: True, BodyCovering: Fur, Probability: 0.2000000000

State: Animal: Robin, Environment: Air, HasShell: False, BearsYoungAs: Eggs, Class: Bird, WarmBlooded: True, BodyCovering: Feathers, Probability: 0.1000000000

State: Animal: Robin, Environment: Land, HasShell: False, BearsYoungAs: Eggs, Class: Bird, WarmBlooded: True, BodyCovering: Feathers, Probability: 0.1000000000

State: Animal: Turtle, Environment: Land, HasShell: True, BearsYoungAs: Eggs, Class: Reptile, WarmBlooded: False, BodyCovering: Scales, Probability: 0.1000000000

State: Animal: Turtle, Environment: Water, HasShell: True, BearsYoungAs: Eggs, Class: Reptile, WarmBlooded: False, BodyCovering: Scales, Probability: 0.1000000000

Мережа Asia

Significant Joint Probabilities with State Descriptions:

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0000132300

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000014700

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000002700

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000000300

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0000068600

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000029400

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000001400

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000000600

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0001190700

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000132300

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000024300

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000002700

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0000617400

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000264600

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000012600

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000005400

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0000006615

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000000735

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000000135

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000000015

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0000012005

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000005145

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000000245

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000000105

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0000654885

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000072765

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000013365

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000001485

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0001188495

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000509355

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000024255

State: VisitAsia: Visit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000010395

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0002513700

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000279300

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000051300

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000005700

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0001303400

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000558600

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000026600

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000011400

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: True, Probability: 0.0001026000

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: False, Probability: 0.0000256500

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Normal, Dyspnea: True, Probability: 0.0019494000

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Normal, Dyspnea: False, Probability: 0.0004873500

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: True, Probability: 0.0000085500

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: False, Probability: 0.0000769500

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Normal, Dyspnea: True, Probability: 0.0001624500

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Normal, Dyspnea: False, Probability: 0.0014620500

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0000125685

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000013965

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000002565

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000000285

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0000228095

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000097755

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000004655

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000001995

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: True, Probability: 0.0000564300

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: False, Probability: 0.0000141075

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Normal, Dyspnea: True, Probability: 0.0010721700

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Normal, Dyspnea: False, Probability: 0.0002680425

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: True, Probability: 0.0000164588

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: False, Probability: 0.0001481288

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Normal, Dyspnea: True, Probability: 0.0003127163

State: VisitAsia: Visit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Normal, Dyspnea: False, Probability: 0.0028144463

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0002619540

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000291060

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000053460

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000005940

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0001358280

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000582120

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000027720

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000011880

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0023575860

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0002619540

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000481140

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000053460

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0012224520

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0005239080

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000249480

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000106920

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0000130977

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000014553

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000002673

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000000297

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0000237699

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0000101871

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000004851

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000002079

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0012966723

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0001440747

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000264627

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000029403

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0023532201

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0010085229

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000480249

State: VisitAsia: NoVisit, Tuberculosis: Present, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000205821

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0259334460

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0028814940

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0005292540

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000588060

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0134469720

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0057629880

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0002744280

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0001176120

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: True, Probability: 0.0105850800

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: False, Probability: 0.0026462700

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Normal, Dyspnea: True, Probability: 0.2011165200

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Normal, Dyspnea: False, Probability: 0.0502791300

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: True, Probability: 0.0008820900

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: False, Probability: 0.0079388100

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Normal, Dyspnea: True, Probability: 0.0167597100

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: Smoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Normal, Dyspnea: False, Probability: 0.1508373900

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0012966723

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0001440747

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000264627

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Present, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000029403

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: True, Probability: 0.0023532201

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Abnormal, Dyspnea: False, Probability: 0.0010085229

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: True, Probability: 0.0000480249

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Present, Bronchitis: Absent, Tb_or_Ca: True, XRay: Normal, Dyspnea: False, Probability: 0.0000205821

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: True, Probability: 0.0058217940

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: False, Probability: 0.0014554485

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Normal, Dyspnea: True, Probability: 0.1106140860

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Present, Tb_or_Ca: False, XRay: Normal, Dyspnea: False, Probability: 0.0276535215

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: True, Probability: 0.0016980232

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Abnormal, Dyspnea: False, Probability: 0.0152822092

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Normal, Dyspnea: True, Probability: 0.0322624418

State: VisitAsia: NoVisit, Tuberculosis: Absent, Smoking: NoSmoking, Lung Cancer: Absent, Bronchitis: Absent, Tb_or_Ca: False, XRay: Normal, Dyspnea: False, Probability: 0.2903619758

Код програми:

Опис мережі Animals

```
from pgmpy.models import BayesianNetwork
from pgmpy.factors.discrete import TabularCPD

def create_animals_model():
    #Define the structure of the Bayesian Network
    model = BayesianNetwork([
        ('Animal', 'Environment'),
        ('Animal', 'HasShell'),
        ('Animal', 'BearsYoungAs'),
        ('Animal', 'Class'),
        ('Class', 'WarmBlooded'),
        ('Class', 'BodyCovering')
    ])

    #Define the CPDs (Conditional Probability Distributions)
    cpd_animal = TabularCPD(
        variable = 'Animal',
        variable_card = 5,
        values = [[0.2], [0.2], [0.2], [0.2], [0.2]],
        state_names = {'Animal': ['Monkey', 'Penguin', 'Platypus', 'Robin',
'Turtle']}
    )
```

```
    cpd_environment = TabularCPD(
        variable = 'Environment',
        variable_card = 3,
        values = [[0, 0, 0, 0.5, 0],
                  [1, 0.5, 0, 0.5, 0.5],
                  [0, 0.5, 1, 0, 0.5]],
        evidence = ['Animal'],
        evidence_card = [5],
        state_names = {'Environment': ['Air', 'Land', 'Water'], 'Animal':
['Monkey', 'Penguin', 'Platypus', 'Robin', 'Turtle']}
    )

    cpd_has_shell = TabularCPD(
        variable = 'HasShell',
        variable_card = 2,
        values = [[0, 0, 0, 0, 1],
                  [1, 1, 1, 1, 0]],
        evidence = ['Animal'],
        evidence_card = [5],
        state_names = {'HasShell': ['True', 'False'], 'Animal': ['Monkey',
'Penguin', 'Platypus', 'Robin', 'Turtle']}
    )

    cpd_bears_young_as = TabularCPD(
        variable = 'BearsYoungAs',
        variable_card = 2,
        values = [[1, 0, 0, 0, 0],
                  [0, 1, 1, 1, 1]],
        evidence = ['Animal'],
        evidence_card = [5],
        state_names = {'BearsYoungAs': ['Live', 'Eggs'], 'Animal': ['Monkey',
'Penguin', 'Platypus', 'Robin', 'Turtle']}
    )

    cpd_class = TabularCPD(
        variable = 'Class',
        variable_card = 3,
        values = [[0, 1, 0, 1, 0],
                  [1, 0, 1, 0, 0],
                  [0, 0, 0, 0, 1]],
        evidence = ['Animal'],
        evidence_card = [5],
        state_names = {'Class': ['Bird', 'Mammal', 'Reptile'], 'Animal':
['Monkey', 'Penguin', 'Platypus', 'Robin', 'Turtle']}
    )

    cpd_warm_blooded = TabularCPD(
        variable = 'WarmBlooded',
        variable_card = 2,
        values = [[1, 1, 0],
                  [0, 0, 1]],
        evidence = ['Class'],
        evidence_card = [3],
        state_names = {'WarmBlooded': ['True', 'False'], 'Class': ['Bird',
'Mammal', 'Reptile']}
    )

    cpd_body_covering = TabularCPD(
        variable = 'BodyCovering',
        variable_card = 3,
        values = [[0, 1, 0],
                  [1, 0, 0],
                  [0, 0, 1]],
        evidence = ['Class'],
        evidence_card = [3],
```

```
        state_names = {'BodyCovering': ['Fur', 'Feathers', 'Scales'], 'Class':
['Bird', 'Mammal', 'Reptile']}
    )

    #Add CPDs to the model
    model.add_cpds(cpd_animal, cpd_environment, cpd_has_shell,
cpd_bears_young_as, cpd_class, cpd_warm_blooded, cpd_body_covering)

    #Validate the model
    assert model.check_model()

    return model
```

Опис мережі Asia

```
from pgmpy.models import BayesianNetwork
from pgmpy.factors.discrete import TabularCPD

def create_asia_model():
    # Define the structure of the Bayesian Network
    model = BayesianNetwork([
        ('VisitAsia', 'Tuberculosis'),
        ('Smoking', 'Lung Cancer'),
        ('Smoking', 'Bronchitis'),
        ('Tuberculosis', 'Tb_or_Ca'),
        ('Lung Cancer', 'Tb_or_Ca'),
        ('Tb or Ca', 'XRay'),
        ('Tb_or_Ca', 'Dyspnea'),
        ('Bronchitis', 'Dyspnea')
    ])

    # Define the CPDs (Conditional Probability Distributions)
    cpd_visit_asia = TabularCPD(
        variable='VisitAsia',
        variable_card=2,
        values=[[0.01], [0.99]],
        state_names={'VisitAsia': ['Visit', 'NoVisit']}
    )

    cpd_smoking = TabularCPD(
        variable='Smoking',
        variable_card=2,
        values=[[0.5], [0.5]],
        state_names={'Smoking': ['Smoking', 'NoSmoking']}
    )

    cpd_tuberculosis = TabularCPD(
        variable='Tuberculosis',
        variable_card=2,
        values=[[0.05, 0.01],
                [0.95, 0.99]],
        evidence=['VisitAsia'],
        evidence_card=[2],
        state_names={'Tuberculosis': ['Present', 'Absent'], 'VisitAsia':
['Visit', 'NoVisit']}
    )

    cpd_lung_cancer = TabularCPD(
        variable='Lung Cancer',
        variable_card=2,
        values=[[0.1, 0.01],
                [0.9, 0.99]],
        evidence=['Smoking'],
        evidence_card=[2],
```

```
        state_names={'Lung Cancer': ['Present', 'Absent'], 'Smoking':
['Smoking', 'NoSmoking']}
    )

    cpd_tb_or_ca = TabularCPD(
        variable='Tb_or_Ca',
        variable_card=2,
        values=[[1, 1, 1, 0],
                [0, 0, 0, 1]],
        evidence=['Tuberculosis', 'Lung Cancer'],
        evidence_card=[2, 2],
        state_names={'Tb_or_Ca': ['True', 'False'], 'Tuberculosis': ['Present',
'Absent'], 'Lung Cancer': ['Present', 'Absent']}
    )

    cpd_xray = TabularCPD(
        variable='XRay',
        variable_card=2,
        values=[[0.98, 0.05],
                [0.02, 0.95]],
        evidence=['Tb_or_Ca'],
        evidence_card=[2],
        state_names={'XRay': ['Abnormal', 'Normal'], 'Tb_or_Ca': ['True',
'False']}
    )

    cpd_bronchitis = TabularCPD(
        variable='Bronchitis',
        variable_card=2,
        values=[[0.6, 0.3],
                [0.4, 0.7]],
        evidence=['Smoking'],
        evidence_card=[2],
        state_names={'Bronchitis': ['Present', 'Absent'], 'Smoking': ['Smoking',
'NoSmoking']}
    )

    cpd_dyspnea = TabularCPD(
        variable='Dyspnea',
        variable_card=2,
        values=[[0.9, 0.7, 0.8, 0.1],
                [0.1, 0.3, 0.2, 0.9]],
        evidence=['Tb_or_Ca', 'Bronchitis'],
        evidence_card=[2, 2],
        state_names={'Dyspnea': ['True', 'False'], 'Tb_or_Ca': ['True',
'False'], 'Bronchitis': ['Present', 'Absent']}
    )

    # Add CPDs to the model
    model.add_cpds(cpd_visit_asia, cpd_smoking, cpd_tuberculosis,
cpd_lung_cancer, cpd_tb_or_ca, cpd_xray, cpd_bronchitis, cpd_dyspnea)

    # Validate the model
    assert model.check_model()

    return model
```

Код розрахунку і обробки ймовірностей

```
from pgmpy.inference import VariableElimination
import itertools
#from Animals import create_animals_model
from Asia import create_asia_model


# Create the model
#model = create_animals_model()
model = create_asia_model()

# Automatically get the list of all variables (nodes) in the model
variables = model.nodes()

# Perform inference
inference = VariableElimination(model)

# Querying the joint probability for the entire network using automatically
fetched variables
joint_prob = inference.query(variables=variables)


# Helper function to map index to state names with variable labels
def get_state_description(factor, index):
    # Get all possible combinations of states
    states = list(itertools.product(*[factor.state_names[var] for var in
factor.variables]))
    selected_state = states[index]

    # Pair variable names with their states and return them as formatted strings
    return ', '.join([f"{var}: {state}" for var, state in zip(factor.variables,
selected_state)])


# Write only significant joint probabilities to file with detailed state
descriptions
#with open('animals_results_filtered_detailed.txt', 'w') as file:
with open('asia_results_filtered_detailed.txt', 'w') as file:
    file.write("Significant Joint Probabilities with State Descriptions:\n")
    for idx, prob in enumerate(joint_prob.values.flatten()):
        if prob > 0:  # Only write non-zero probabilities
            state_description = get_state_description(joint_prob, idx)
            file.write(f"  State: {state_description}, Probability:
{prob:.10f}\n")
```

Все можна переглянути за посиланням на github: https://github.com/Kinelan/Bayes/tree/main/Lab%201

Висновки

Основна мета цієї лабораторної полягала в тому, щоб змоделювати й проаналізувати дві різні Байєсівські мережі, коректно обчисливши ймовірності станів для кожної з них.

Для цього було побудовано дві Байєсівські моделі мережі: мережа Animal та мережі Asia, кожна з яких має власну структура власні змінні і ймовірність значень для кожної змінної. Після цього були обраховані **спільні ймовірності** для кожної моделі за допомогою алгоритму **Variable Elimination**, що дозволило

визначити ймовірності для різних комбінацій станів змінних. Після цього всі значення були оброблені і у файл були записані лише, які мали хоч якусь релевантність (тобто не були нульовими).