CLASSIFYING DISORDERS OF PROSTATE USING MASTER-SLAVE CONFIGURATION OF NEURAL NETWORKS

A Project based on the research paper (CIB2011) by Asst.Prof.Dr. Anilkumar K.G

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Abstract

- This project classifies disorders of prostate into **Benign Prostatic Hyperplasia (BPH)**, **Prostate Cancer (PC)** and **other inflammations** using master-slave configuration of two Back propagation Neural Networks (BPNNs).

- Symptoms from elderly men including *urinary dribbling*, *urinary hesitancy*, *feeling of non-empty bladder*, *burning urination*, *hematuria*, *testosterone level* and others are given as the attributes of the **master BPNN**.

- The **slave BPNN** has the following attributes: output of the master BPNN (symptom level), free prostate specific antigen (PSA) level, insulin-like growth factor-1 (IGF-1), CAG (DNA genetic codon glutamate) repeat, heredity, PCA3 urine level, JM-27 blood level and others. The slave BPNN classifies prostate disorders into PC, BPH and other inflammations.

- Data from *Gleason score* is used to detect PC stages.

Introduction

- The advantage of neural networks based information processing lies in its ability to recognize and model non-linear relationships between data.

- Though conventional statistical methods can be successfully used to attempt to model nonlinear relationships, **neural networks provide a comparatively easier way to perform the same type of analysis**
  - Because of their ability to recognize data relationships between variables that may either be counterintuitive or not obvious to the casual user

Introduction

- Concept of data mining is applied in this paper
  - Seen datasets (training datasets) generated based on patients symptoms, medical tests and heredity are analyzed using master slave configuration of two 3-layer backpropagation neural networks (BPNN)
    - A neural network is initially "trained" or fed with large amounts of data and rules about the data relationships.
  - Both neural networks are trained by backpropagation algorithm with their seen datasets until the Mean Squared Error (MSE) is reduced to a value less than 0.01.

Prostate Gland
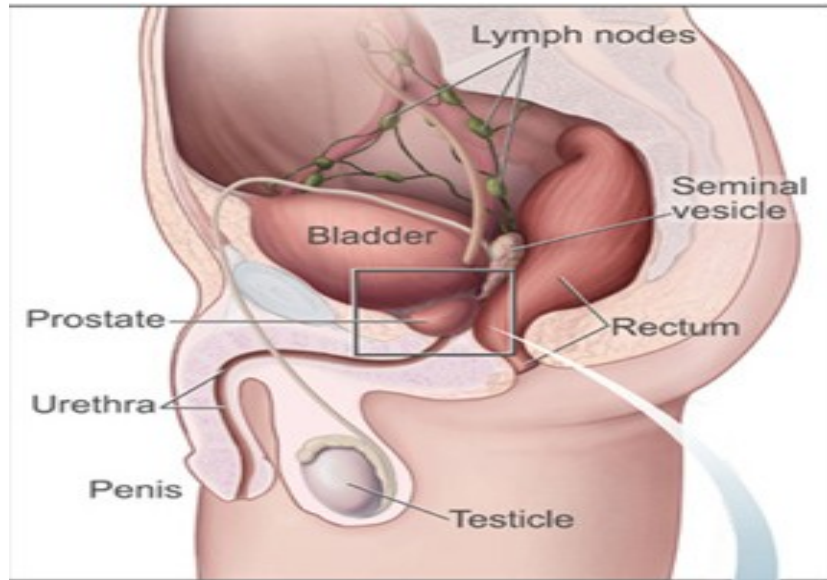
This shows the prostate and nearby organs.
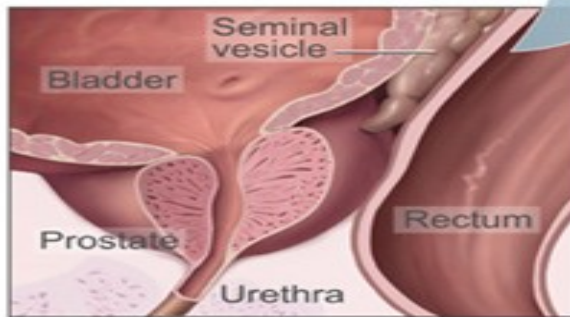
This shows the inside of the prostate, urethra, rectum, and bladder.

The prostate is a small, walnut-sized structure that makes up part of a man's reproductive system. It wraps around the urethra, the tube that carries urine out of the body.

Figure1 Prostate gland*

*Courtesy of wikipedia.com

Details of Common Prostate Disorders in Elderly Men - BPH

- **Benign Prostatic Hyperplasia (BPH):**
  - generally begins in men in their 30s and gradually growing and eventually showing symptoms after 50
  - The signs and symptoms of BPH vary, but usually involve changes or problems with urination include
    - *trouble starting a urine stream* or *making more than a dribble, passing urine often, feeling that the bladder has not fully emptied, a strong and sudden urge for urination, hematuria, a weak or slow urine stream, stopping and starting again several times while passing urine*

Details of Common Prostate Disorders in Elderly Men - BPH

- At the moment when BPH is suspected, several tests like DRE, PSA blood test and others are used to rule out cancer

- Several studies have shown BPH produces elevations in **total serum PSA** that overlap with levels associated with malignancy

Details of Common Prostate Disorders in Elderly Men - PC

- Just as the cause of an enlarged prostate is not known, the cause of **prostate cancer (PC)** is also not established
  - It is believed that factors such as age, race, life style, family history and hereditary factors may increase the risk of developing cancer in prostate.
- PC is common in men who are over 50 and it is the second most common cause of cancer related death in men
  - PC usually does not show symptoms in the early stages. There are no signs or symptoms similar to that of BPH.

Details of Common Prostate Disorders in Elderly Men - PC

- Under normal conditions, prostate cells, just like all other cells in the body, are constantly reproducing and dying.

- **Prostate Cancer** (**PC**): Cells in the prostate are constantly reproducing but not dying.
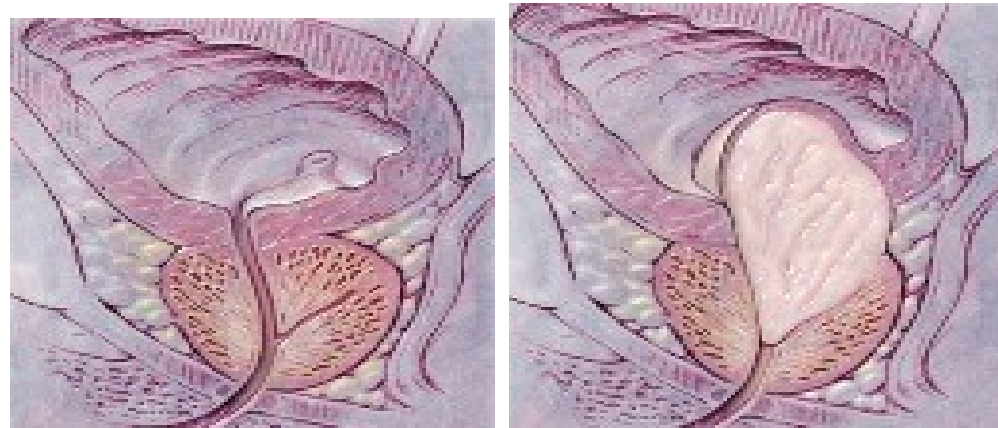
Figure 2 (a) Normal prostate   (b) Inflamed prostate

*Courtesy of wikipedia.com

Details of Common Prostate Disorders in Elderly Men - PC

- **Testosterone** directly stimulates the growth of both normal prostate tissue and cancer cells.
  - The studies showed that those with the highest levels of free testosterone in the blood (>900 nanogram per deciliter) were the most likely to have PC.

Details of Common Prostate Disorders in Elderly Men

- An initial stage of PC usually causes urinary related symptoms similar to that of BPH; in general, the symptoms are categorized into two groups:

  - *Apparent Symptoms*: inability to urinate, interruption of urinary stream, frequent urination, pain or burning during urination, urinary hesitancy, urinary dribbling, urinary retention, hematuria, abdominal pain, back or leg pain, low RBC count, etc.

  - *Metastatic Symptoms*: Metastatic symptoms include weight loss and loss of appetite; bone pain with or without pathologic fracture; and lower abdominal pain.

    - Furthermore, the genetic study reveals that family history (heredity) responsible for 5-10% PC in men.

What is common in PC and BPH?

- Both BPH and PC, can cause similar problems.
- The cause of PC is unknown and the is not thought to be related to BPH.
- The factors that contribute to the risk of PC include *advancing age*, *heredity*, *hormonal influences*, *toxins*, and *application of chemicals*.
- In advanced cases, PC may enlarge and press on the urethra. As the tumor continues to grow, it can completely block the flow of urine.
- Most of these symptoms are common in men with BPH.
- Hence it is also desirable to differentiate between individuals with elevated PSA levels due to BPH, and individuals with elevated PSA due to PC.
- There is no evidence that BPH leads to PC; symptoms of both disorders are similar, and it is possible to have BPH and PC at the same time.
- Normally, BPH responds well to treatment.

Details of PSA Screening

- PSA (Prostate Specific Antigen) is a protein produced by prostate epithelial cells and it is not easy to conclude that the elevated blood PSA level is due to PC or BPH.

- The PSA level is usually higher that 4ng/mL in people with PC

- Elevation in PSA greater than 4.0ng/mL was associated with increased of PC or BPH.

Details of PSA Screening

- In blood serum, PSA is primarily bound to the protease inhibitor α_1-antichymotrypin, and only a small fraction exists in an unbound or free form.

- Hence the total serum PSA is the sum of PSA bound to α_1-antichymotrypin and unbound (free) PSA.

- Several recent studies have shown that the percentage **serum free PSA is lower** in patients with PC than in those with BPH.

- The PSA that **circulates freely** in the blood tends to be associated with BPH whereas the PSA that is **bound to protein** tends to be linked with PC

Details of PSA Screening

- In a large prospective study by Catalona et al.[1] patients with minimal DRE (Digital Rectal Examination) and serum PSA between 2.6 and 4.0ng/mL, 22% of 322 men who under went biopsy were found to have PC.

- This indicates that traditional PSA elevation is not enough to diagnose PC
  - In conclusion, indications such as **free testosterone level** in blood, IGF-1(insuline like growth factor-1), CAG length, GGC length and others and therefore other techniques need to be considered.

PCA3 Urine Test and JM27 ELISA Test

- Prostate Cancer Gene-3 (PCA3) is a new gene based test carried out on a urine sample.

- PCA3 is highly specific for the diagnosis of PC developed by researchers at the University of Michigan.

- The PCA3 test is based on the specific **messenger RNA** (mRNA) molecule related to the PC.

- A low level of PCA3 is expressed by normal prostate cells and the higher PCA3 scores indicate the greater likely hood of PC
  - PCA3 score < 5 indicates low risk of cancer levels and PCA3 score > 100 high risk of PC and cutoff PCA3 is 35.

PCA3 Urine Test and JM27 ELISA Test

- The early data look promising the PCA3 test must still be regarded as a 'work in progress' from several perspectives. That is, factors regulating PCA3 gene expression are not yet clearly defined

PCA3 Urine Test and JM27 ELISA Test

- Researchers reported higher levels of a protein made by a gene known as JM-27 in men with severe BPH

- This androgen-regulated gene has been found to be a marker of **symptomatic BPH**.

- This leads the development of a serum based enzyme-linked immuno-sorbent assay (ELISA) for measuring the JM-27 protein in blood.

- Men with higher levels of JM27 protein show less severe form of BPH.

- As per the researchers, the asymptotic BPH cannot be identified with JM27 ELISA

Molecular Factors in the Assessment of PC Risk

- The studies found that several areas of molecular investigations are preliminary linked to PC risk:
  - First, a series of polymorphisms have been described in the molecules involved both in the signal transduction and metabolism of androgenic hormones,
  - second, a collection of recent experiments have clearly implicated insulin-like growth factor-1 (IGF-1) in PC risk. Increase IGF-1 in men with PC but not with BPH. That is, increasing plasma levels of IGF-I were directly linked to increasing PC risk.

Molecular Factors in the Assessment of PC Risk

- The Androgen Receptor (AR) gene is located on the X-chromosome (Xq11-q12);

- the first axon of the AR gene contains a region of CAG (DNA genetic codon glutamate) repeats which encode for a series of glutamine residues located in the middle of the androgen receptor's transactivation domain [1].

- **Normal men may have anywhere between 11 and 31 CAG repeat in the AR gene** with a corresponding number of glutamate in the androgen receptor protein.

Molecular Factors in the Assessment of PC Risk

- Several studies indicate that PC risk may be linked to androgen receptor gene CAG repeat length.

- It was noted approximately a twofold increased risk of PC in men having a CAG repeat length of less than 20.

- A recent study indicates that approximately 60% of African American men have < 20 CAG repeat when compared to others in US.

  – That may be the reason they have more chance of PC.

# Molecular Factors in the Assessment of PC Risk

- In addition to CAG repeat in AR, there is GGC (DNA genetic codon Glycine) repeat is also noticed.

- Studies indicate that men with **less than 17 GGC repeats** have a 1.6 fold relative risk of PC compared to men with more than 17 GGC repeats

Gleason Score

- **Gleason score** is a significant biologic manifestation of prostate biopsy

  - Under normal conditions, prostate cells, just like other cells in the body, but cancer cells look different, and the degree to which they look different from normal cells is what determines the Gleason score.

    - "Low-score" tumor cells tend to look very similar to normal cells,

    - "high-score" tumor cells have mutated so much that they often barely resemble the normal cells.

Gleason Score (Cont.)

- The Gleason scoring system accounts for the five distinct patterns that prostate tumor cells tend to go through as they change from normal cells. The scale runs from 1 to 5, where 1 represents cells that are very nearly normal, and 5 represents cells that don't look much like prostate cells at all.
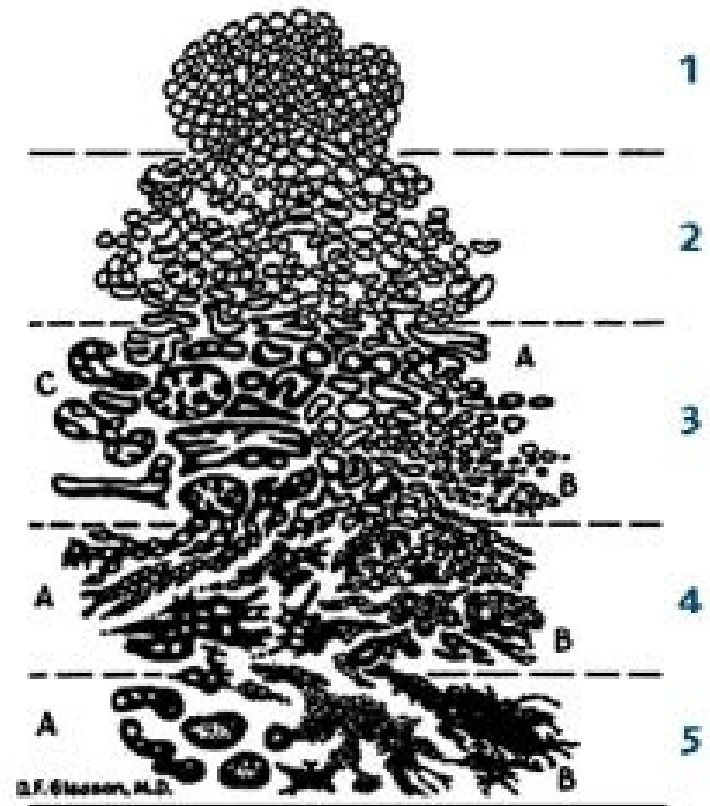
Appearance of cancer cells, ranked according to the Gleason Grade.

Figure 3 Gleason Score

Gleason Score (Cont.)

Table 1 Details of Gleason score

Gleason Score	Meaning
1	Prostate cells are very nearly normal
2	Prostate cells are normal
3	Prostate cells are not normal
4	Prostate cells are invaded by tumor cells (more than 50%)
5	100% of prostate cells are tumor cells

PSA test with Gleason score

Table 2 shows the details of PSA test with Gleason score

PSA and Gleason score	Explanation	Suggested remedy
PSA is 4-10 ng/mL & Gleason (1-2)	Normal men	Biopsy without additional free PSA test
PSA < 10 ng/mL & Gleason < 3	No or minimal findings of tumor cells	Surgery/antibiotic therapy
PSA > 10 ng/mL & Gleason $\geq$ 4	Findings of T3 stage	Radiation/ chemotherapy

Tumor Stages of PC

Table 3 PC tumor stages by Tumor-node-metastasis (TNM)

Stage	Explanation
T1	Clinically in apparent tumor
T1a	Tumor in $\leq$ to 5% of tissue resected
T1b	Tumor in $>$ to 5% of tissue resected
T1c	Tumor identified by Gleason grading
T2	Tumor confined within prostrate
T2a	Tumor involving $<$ half of a lobe
T2b	Tumor involving $\leq$ one lobe
T2c	Tumor involving both lobs
T3	Tumor extending through the prostatic capsule
T3a	Extra-capsular extension
T3b	Tumor invading seminal vesicle(s)
T4	Tumor spread adjacent organs

Why BPNN in this paper?

- The following reasons support the decision of using BPNN in the classification of prostate disorders:
  - It is difficult to select a proper test for a case with a patient who has both BPH and PC.
  - The PSA readings are abnormal in most men diagnosed with PC.
  - Asymptotic BPH cannot be clarified through JM-27 ELISA test.
  - PCA3 urine test still lacks its generality to apply many cases.
  - Errors in the Gleason score are common and most often result in under-grading of the actual tumor stage.
    - Hence Gleason score is applied only after the conformation of the PC.

The Structure of Prostate Disorder Classification Scheme

- In this paper, each elderly man with age $\geq$ 50 years has identified with at most **eight symptoms**.

  - At this point, an elderly man with these symptoms (at least one) is believed as a patient.

- With these eight symptoms, a patient M_1 can be represented as $\{p_{11} \wedge p_{12} \wedge \ldots \wedge p_{18}\}$, where p_{11}, p_{12},.., etc., are the conjunction of the symptoms of M_1.

  - These eight symptom attributes are for estimating the **symptom_level (SL)** of a patient and are given to the master BPNN: *non-emptied bladder* (*R*), *urinary hesitancy* (*H*), *urinary dribbling* (*D*), *frequent urination* (F), *burning urination* (*B*), *hematuria* (*T*), *back pain* (*P*), and *free testosterone level in blood* (*O*).

The Structure of Prostate Disorder Classification Scheme

- The following attributes are given to the **slave BPNN** in order to generate a ***prostate value (PV)*** of a patient: *symptom_level* (*SL*), *serum free PSA* (*S*), *IGF*-1 *level*, *CAG repeat*, *GCC repeat, heredity* (*HR*), *PCA*3 *urine level*, and *JM*27 *blood level*.

- Based on ***PV*** (available in *prostate queue*), the strength of BPH and PC of a set of patients can be classified.

  - The Gleason score and TNM evaluation of prostate cells will detect the cancer stages (as given in Tables 2 and 3).

- Figure 2 shows the structure of prostate disorder classification scheme.

  - The proposed prostate disorder classification system works with a set of patients rather than a single patient at a time.

The Structure of Prostate Disorder Classification Scheme

– Figure 2 shows master and slave neural networks with their unseen dataset (patient symptoms), seen datasets, symptom queue, prostate queue, convergence test (for both master and slave), and Gleason score test.
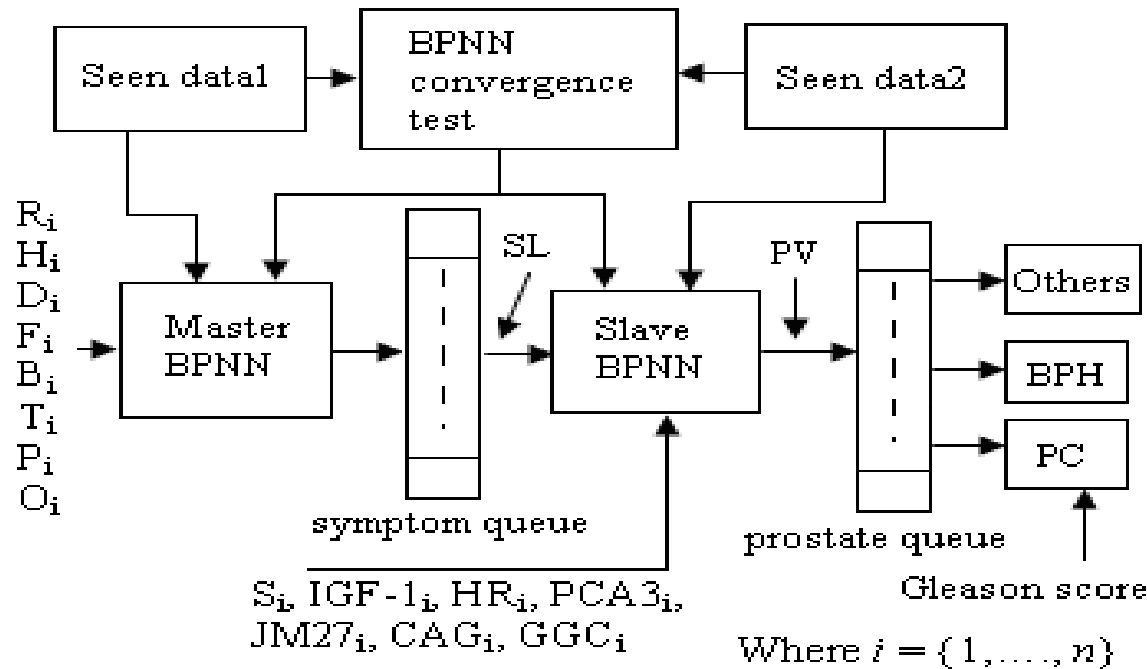

Figure 2. Structure of the prostate disorder classification scheme

The Structure of Prostate Disorder Classification Scheme

- Figure 3 shows two 3-layer neural networks with topology 8 20 1(one input layer with eight data inputs, one hidden layer with twenty neurons, and an output layer with one data output) each with eight input variables and one output as master-slave configuration.
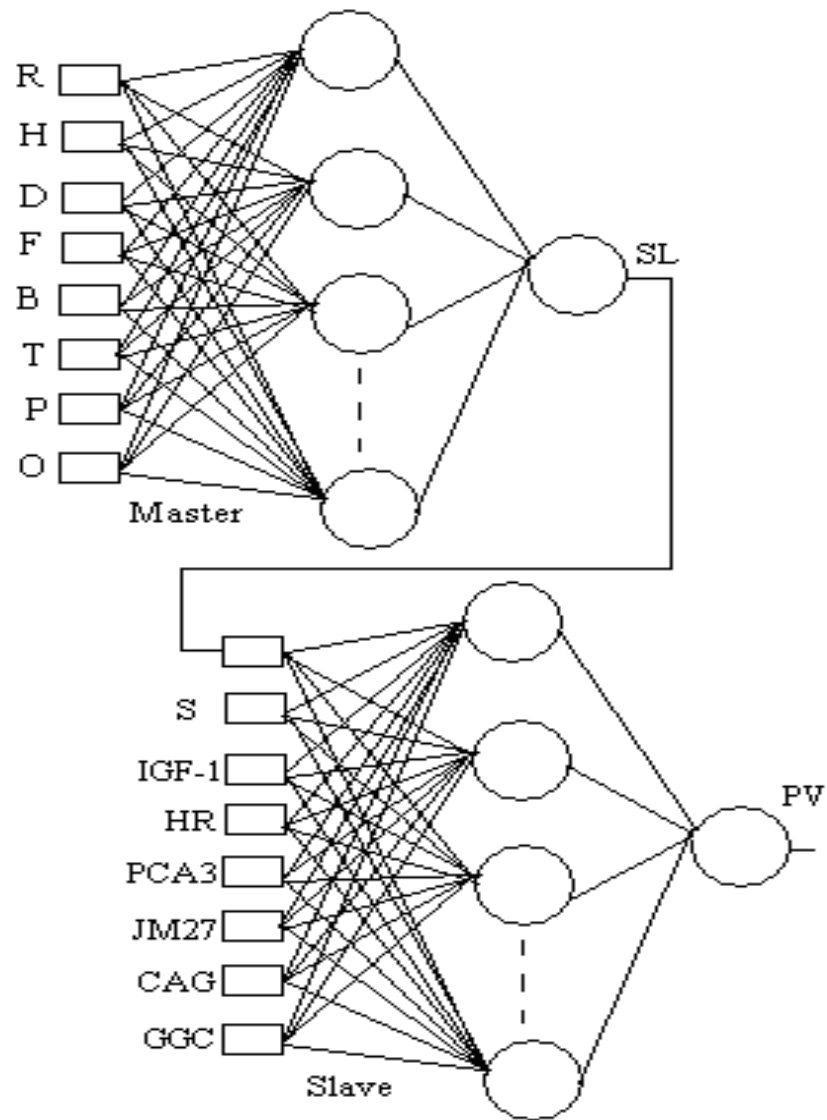
Figure 3. Two 3-layer BPNNs with input and output

Seen Dataset for Master and Slave Neural Networks

- To generate seen dataset for the master and slave neural networks based on their assigned attributes (symptoms), a process of data normalization is need to be applied and is referenced with the clinical dataset [8].

- For this paper, each symptom attribute of a patient is converted into levels of five positive real numbers as 0.1, 0.3, 0.5, 0.7, and 0.9.

- A numerical value 0 indicates a non symptom situation of a patient.

- The eight symptom-attributes of **master BPNN** with their assigned real numbers and linguistic terms are described below:

Seen Dataset for Master Neural Network

- *Ri*, *non-emptied bladder* of patient *i* has values [0.1 (*very l*ow), 0.3 (*low*), 0.5 (*not low*), 0.7 (*high*), 0.9 (*very high*)].
- *-Hi*, *urinary hesitancy* of patient *i* has values [0.1 (*very low*), 0.3 (*low*), 0.5 (*not low*), 0.7 (*high*), 0.9 (*very high*)].
- *Di*, *urinary dribbling* of patient *i* has values [0.1 (*very low*), 0.3 (*low*), 0.5 (*not low*), 0.7 (*high*), 0.9 (*very high*)].
- *-Fi*, *frequent urination* of patient *i* has values [0.1 (*very low*), 0.3 (*low*), 0.5 (*not low*), 0.7 (*high*), 0.9 (*very high*)].
- *-Bi, burning urination* of patient *i* has values [0.1 (*very low*), 0.3 (*low*), 0.5 (*not low*), 0.7 (*high*), 0.9 (*very high*)].
- *Ti, hematuria* of patient *i* has values [0.1 (*very low*), 0.3 (*low*), 0.5(*not low*), 0.7 (*high*), 0.9 (*very high*)].
- *Pi, back pain* of patient *i* has values [0.1 (*very less*), 0.3 (*less*), 0.5(*not less*), 0.7 (*strong*), 0.9 (*very strong*)].
- *Oi, free testosterone blood level* of patient *i* has values [0.1 (*very low*), 0.3 (*low*), 0.5(*not low*), 0.7 (*high*), 0.9 (*very high*)].
- Similarly, the output of the master BPNN can be indicated as;
- *SLi, symptom_level* of a patient *i* has values varying from 0.001 (*negligible*) to 0.99 (*very high*).

Seen Dataset for Master Neural Network

- Based on the numerical values and linguistic terms of the symptoms of a patient, **subjective criteria** for generating seen dataset for finding *SL* (symptom_level) of a patent are listed below:
- A patient with symptoms of *low*/*very low* non-emptied bladder, *low*/*very low* urinary hesitancy, *low*/*very low* frequent urination, no burning urination (value below 0.1), no hematuria, no back pain, and *very low* testosterone level (0.3-0.69); will have a *negligible* symptom_level.
- A patient with symptoms of *low* non-emptied bladder, *low* urinary hesitancy, *low* frequent urination, *low* burning urination, *low* hematuria, *less* back pain, and *low* testosterone level; will have a *low* symptom_level.
- A patient with symptoms of *not low* non-emptied bladder, *low* urinary hesitancy, *low* frequent urination, *not low* burning urination, *not low* hematuria, *not less* back pain, and *not low* testosterone level; will have a *not low* symptom_level.
- A patient with symptoms of *no* non-emptied bladder, *no* urinary hesitancy, *no* frequent urination, *very high* burning urination, *no* hematuria, *no* back pain, and *no* testosterone level; will have a *negligible* symptom_level.
- A patient with symptoms of *not low* non-emptied bladder, *not low* urinary hesitancy, *high* frequent urination, *high* burning urination, *not low* hematuria, *less* back pain, and *high* testosterone level; will have a *high* symptom_level.
- A patient with symptoms of *high*/*very high* non-emptied bladder, *high*/*very high* urinary hesitancy, *high*/*very high* frequent urination, *high*/*very high* burning urination, *high*/*very high* hematuria, *strong*/*very strong* back pain, and *high* testosterone level; will have a *high*/*very high* symptom_level.
- Based on the proposed criteria, there are 100 seen dataset patterns generated for the initial training of the master BPNN.

Seen Dataset for Master Neural Network

- The output data patterns of the seen dataset of the master BPNN is categorized into the four sections:

    (i) values of *SL* in the range including 0.55 to 0.99 indicate *strongest symptom* levels,

    (ii) values of *SL* in the range including 0.2 to 0.54 indicate *lowest symptom* levels,

    (iii) values of *SL* in the range including 0.1 to 0.19 are considered as *asymptotic symptom* levels and

    (iv) the values of *SL* below 0.1 are *negligible symptom* levels. In this paper, men with negligible symptom levels are exempted from further procedures.

Seen Dataset for Slave Neural Network

- **The seven attributes (except the symptom_level *SL*) of slave BPNN with their assigned real numbers and linguistic terms are given below:**

- *Si*, *serum free PSA* level of patient *i* has values [0.1 (*very low*), 0.3 (*low*), 0.5 (*not low*), 0.7 (*high*), 0.9 (*very high*)] – Free PSA high in patients with BPH and bound PSA high in patients with PC.

- *-IGFi*, *insulin-growth factor* of patient *i* has values [0.1 (*very low*), 0.3 (*low*), 0.5 (*not low*), 0.7 (*high*), 0.9 (*very high*)] – Increased IGF is due to PC and not with BPH.

- *-HRi*, *heredity* of patient *i* has values [0.1 (*very far*), 0.3 (*far*), 0.5 (*not far*), 0.7 (*near*), 0.9 (*very near*)] – Heredity is related to PC.

- *-PCA3i, prostate cancer gene3* level of patient *i* has values [0.1 (*very low*), 0.3 (*low*), 0.5(*not low*), 0.7 (*high*), 0.9 (*very high*)] – Higher PCA3 indicates greater risk of PC.

- *JM27i, prostate protein* of patient *i* has values [0.1 (*very low*), 0.3 (*low*), 0.5(*not low*), 0.7 (*high*), 0.9 (*very high*)] –Low levels of JM27 indicates severe BPH.

- *CAGi, DNA code on glutamate* repeat of patient *i* has values [0.1 (*very less*), 0.3 (*less*), 0.5(*not less*), 0.7 (*high*), 0.9 (*very high*)] – Less repeat length of *CAG* indicates high PC risk.

- *GGCi, DNA code on glycine* repeat of patient *i* has values [0.1 (*very less*), 0.3 (*less*), 0.5(*not less*), 0.7 (*high*), 0.9 (*very high*)] – Less repeat length of *GGC* indicates high PC risk.

- Similarly, the output of the slave BPNN can be indicated as;

- *PVi, prostate value* of a patient *i* has values varying from 0.01 (*very low*) to 0.99 (*very high*).

Seen Dataset for Slave Neural Network

- Based on the numerical values and linguistic terms of the attributes of the slave BPNN, criteria for generating seen dataset for finding *PV* of a patent are:

- A patient with *very low* symptom_level, *very low* serum free PSA, *very low* insulin-growth factor, no heredity, *very low* PCA3 level, *very high* JM27 level, *high* CAG repeat, *high* GGC repeat; will have a *very low* prostate value.

- A patient with *not low/high* symptom_level, *low/very low* serum free PSA, *high* insulin-growth factor, *near/very near* heredity, *high/very high* PCA3 level, *not low/high* JM27 level, *less/very less* CAG repeat, *less/very less* GGC repeat; will have a *high/very high* prostate value.

- A patient with *high* symptom_level, *high* serum free PSA, *very low* insulin-growth factor, *far* heredity, *very low* PCA3 level, *low/very low* JM27 level, *high/very high* CAG repeat, *high/very high* GGC repeat; will have a *low* prostate value.

- A patient with *not low* symptom_level, *not low* serum free PSA, *high* insulin-growth factor, *near* heredity, *high* PCA3 level, *high* JM27 level, *less* CAG repeat, *less* GGC repeat; will have a *high* prostate value.

- A patient with *not low* symptom_level, *low/very low* serum free PSA, *low/very low* insulin-growth factor, *no* heredity, *very low* PCA3 level, *low/very low* JM27 level, *high* CAG repeat, *high* GGC repeat; will have a *low* prostate value.

- A patient with *high* symptom_level, *not low* serum free PSA, *not low* insulin-growth factor, *near/very near* heredity, *high* PCA3 level, *high* JM27 level, *not less* CAG repeat, *high* GGC repeat; will have a *not low* prostate value.

Seen Dataset for Slave Neural Network

- Based on the proposed criteria, there are 100 seen dataset patterns generated for the initial training of the slave BPNN.

- The output data patterns of the seen dataset of the slave BPNN are categorized into four sections:

  (i) values of PV starting from 0.55 to 0.99 indicates PC,

  (ii) values of PV starting from 0.1 to 0.45 indicates BPH,

  (iii) values of PV starting from 0.46 to 0.54 indicates a situation of both PC and BPH and

  (iv) values of PV below 0.1 indicates other prostrate inflammations.

Prostate Disorder classification Procedure

- Select both master and slave BPNNs with proper topology and train them with seen datasets using backpropagation algorithm.

- The proposed convergence test measures the acceptability of the selected BPNNs.

- Generate values (in the range 00-0.99) of unseen attributes for master network (such as R, H, D, F, B, T, P, and O).

- Master BPNN generates symptom level, SL in the symptom queue based on its attributes for a set of n patients as: $\{SL1, SL2, …, SLn\}$.

- Higher value of SL (0.55 to 0.99) indicates *strongest symptom* and lower value (0.2 to 0.54) indicates *lowest symptom*. The value of SL in the range including 0.1 to 0.19 is considered as *asymptotic* level. Finally, the value of SL below 0.1 is assumed as the *negligible* level. Men with negligible SL will be exempted from further procedures.

- Based on the SL and attributes such as S, IGF, HR, $PCA3$, $JM27$, CAG and GGC, the slave BPNN generates prostate value, PV in the prostate queue.

- Higher value of PV (0.55 to 0.99) indicates PC levels and lower PV (0.1 to 0.45) indicates levels of BPH. The PV levels from 0.46 to 0.54 indicate a patient with both BPH and PC. The PV below 0.1 indicates that prostate inflammation is neither due to BPH nor PC.

- Finally, PC stages will be analyzed with Gleason score and TNM system.

Simulation

- The simulation is written in C# and is made to analyze the efficiency of the proposed BPNN based prostate disorder classification procedure.

  – Results from the simulation depend on seen datasets and unseen datasets of master and slave neural networks.

  – In this paper, 100 men (age $\geq$ 50 years) were selected to classify their prostate disorders based on their symptoms.

- Based on the Eq. (1), both master and slave neural networks are acceptable with correlation values +0.9978 and +0.988 respectively.

  – Figure 4 shows the *SL* of 100 men by the master BPNN. Table 4 shows the *SL* type of 100 men based on the Figure 4. It was seen that patient with numbers 11, 19, 23, 62, 71, 83, 92, and 98 have negligible *SL* values (*SL* < 0.1) and are forbidden from further procedures.
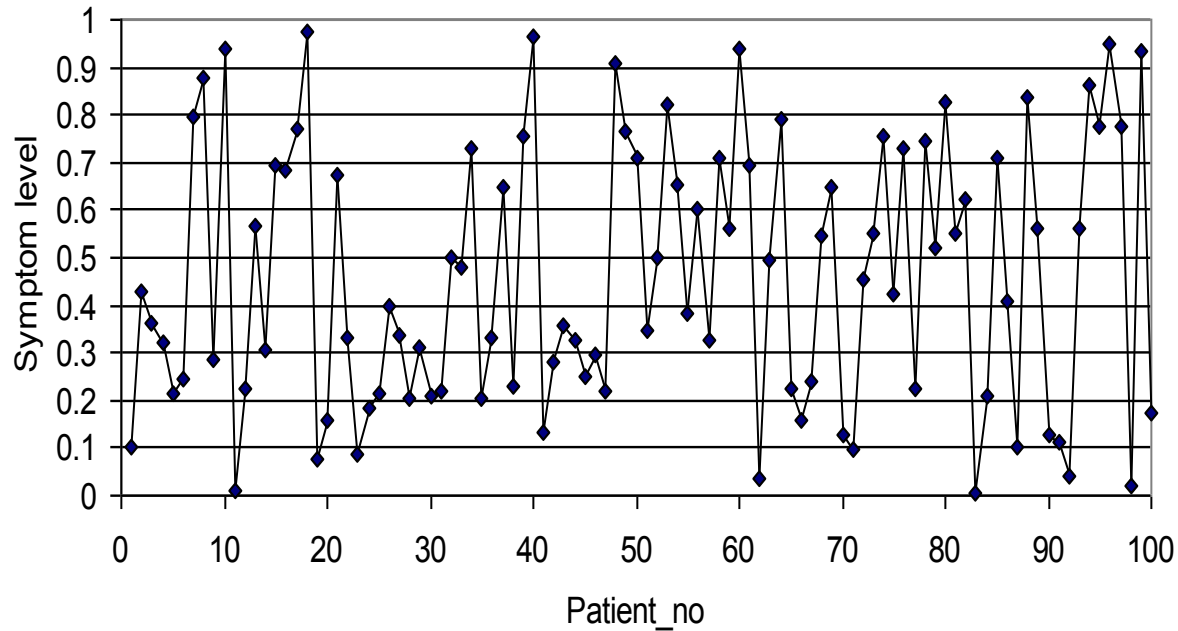
Simulation

Figure 4. Symptom_level of 100 men

Simulation

Table 4
Symptom levels classification of 100 men by master
BPNN

Patient no.	SL type	Patient size
7,8,10,13,15,16,17, 18,21,34,37,39,40, 48,49,50,53,54,56, 58,59,60,61,64,69, 73,74,76,78,80,81, 82,85,88,89,93,94, 95,96,97,99	Strongest	41
2,3,4,5,6,9,12,14,22, 25,26,27,28,29,30,31, 32,33,35,36,38,42,43, 44,45,46,47,51,52,55, 57,63,65,67,68,72,75, 77,79,84,86	Lowest	41
1,20,24,41,66,70,87, 90,91,100	Asymptotic	10
11,19,23,62,71,83,92, 98	Negligible	8

Simulation

- Figure 5 shows *PV* (prostate value) of 92 patient (eight men with negligible symptom_level were exempted) by slave BPNN.
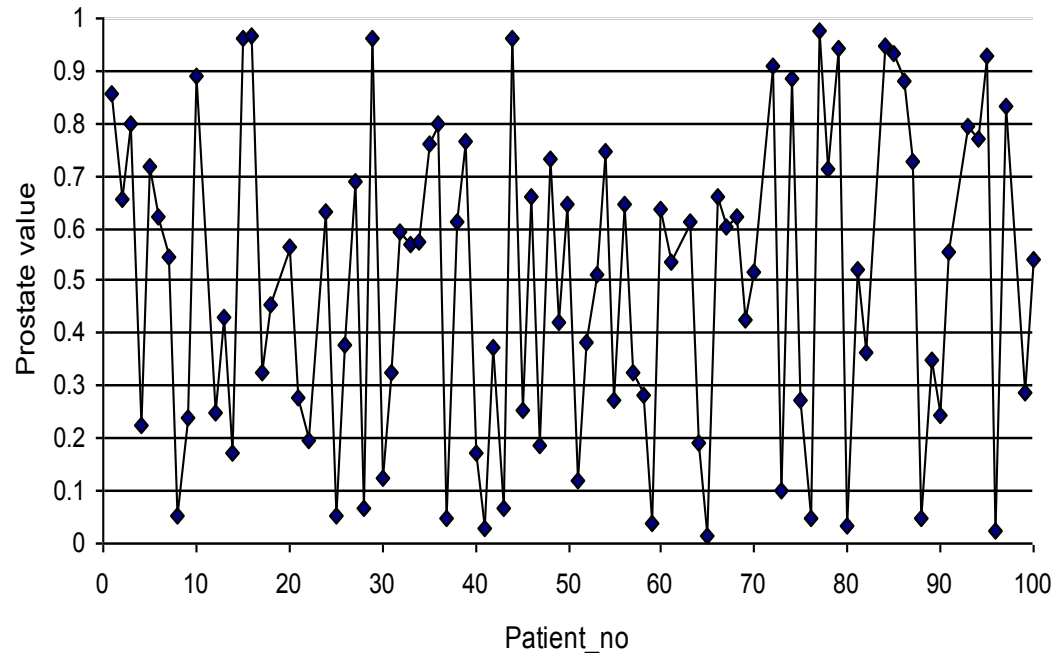

Figure 5. Prostate value of 92 men

Simulation

- Based on the *PV* from Figure 5, prostate disorders of 92 men are shown in Table 5: 44 men have confirmed PC, 29 men have BPH, 6 men have both BPH and PC and 13 men have prostatic inflammations due to unknown reasons.

- It is also noticed that patient no. 90 has asymptotic symptom level and is diagnosed with BPH

- And six men (1, 20, 24, 66, 87 and 97) have asymptotic symptom levels and are diagnosed with confirmed PC.

- Similarly, two men (70 and 100) have asymptotic symptom levels and are diagnosed with both PC and BPH.

Simulation

Table 5
The disorder classification result of prostate by slave BPNN

Patient No.	Prostate disorder	Patient size
1,2,3,5,6,10,15,16,20,24,27, 29,32,33,34,35,36,38,39,44, 46,48,50,54,56,60,63,66,67, 68,72,74,77,78,79,84,85,86, 87,91,93,94,95,97	PC	44
4,9,12,13,14,17,18, 21,22,26,30,31,40,42,45,47, 49,51,52,55,57,58,64,69,75, 82,89,90,99	BPH	29
7,53,61,70,81,100	BPH and PC	6
8,25,28,37,41,43,59, 65,73,76,80,88,96	Others	13

Simulation

- Table 6 shows tumor stages of 44 patients with confirmed PC by Gleason score and tumor-node-metastasis (TNM).

Table 6
Tumor stages of 44 patients with PC

Tumor Stage	Patient size	PV
T1	11.364%	< 0.6
T2	54.55%	$0.6 \leq PV < 0.8$
T3	11.364%	$0.8 \leq PV < 0.9$
T4	22.73%	≥ 0.9

Conclusion

- From the context of many research studies, it was established that in certain men PC is independent of PSA levels.

- Moreover, further studies revealed that the current PCA3 urine test and JM27 blood test for PC and BPH need further clarifications.

- Hence this paper tries to figure out a proper classification scheme for prostate disorders such as PC and BPH from their biological signatures and flaws in current prostrate screening procedures using the application of backpropagation neural networks.

- It is also ascertained that men with strong symptom levels and those with low symptom levels were evaluated equally for both asymptotic and symptotic prostatic disorders.

- Even though in normal case it is difficult to identify men with both BPH and PC from their symptoms, the proposed approach shown its ability in classifying such cases.

Thank you!