

Initial report on analysis of the Anganwadi dataset 2010

Avishek Sen Gupta
ThoughtWorks

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1 Abstract

This report summarises the results of exploration of the Anganwadi dataset provided by the Akshara Foundation. The analysis aims to characterise the structure of the data, and reveal trends (which would otherwise be obscured by the format of the source data) which may inform strategy through subsequent prediction and/or classification procedures.

2 Methodology

2.1 CRISP-DM

CRISP-DM is a process model distilled from the most common approaches used in data mining procedures. It stands for Cross Industry Standard Process for Data Mining. Not so much a prescription as a collection of 'good practices' followed by data mining professionals, **CRISP-DM** has the following characteristics.

- Domain-neutral
- Tool-neutral
- Provides a structural approach to the data mining process

CRISP-DM segregates data mining endeavours into the following phases.

- Business Understanding
- Data Understanding
- Data Preparation
- Modeling
- Evaluation
- Deployment

2.2 Relevance of CRISP-DM to this report

As far as this report is concerned, the relevant or most significant phases we focus on are:

- Data Understanding
- Data Preparation
- Modeling

Work on the Evaluation step is still preliminary, and will probably be the subject of another report. In a full-fledged project, the rest of the activities upstream and downstream to the above list will assume more importance, and require corresponding investment.

3 Data Preparation

3.1 Nature of the source data

The dataset comes from the education domain. The source data is a file, with each line corresponding to a single student evaluation record. Roughly, there are 29000 records, prior to any data sanitisation. Each line is pipe(|)-delimited into multiple fields. The fields salient to this analysis are listed below:

- Location of the student's school
- Language of the student
- Student's score before intervention
- Student's score after intervention

The score is not a single number, it is a set of 56 responses marked as 0/1. Generally, a 1 may be treated as a favourable answer, therefore, adding them up to get a single aggregate score has natural ordering: a sense of who did better. We reproduce two such records below, with the original formatting.

[illegible]

Looking at the second row, we see that the location of the Anganwadi is BADAMAKAAN I, the student is female and speaks Urdu. The first contiguous set of 0s and 1s is the pre-intervention score, and the next set is the post-intervention one.

3.2 Data representation

3.2.1 Data store

Before any sort of sanitisation or analysis may be performed, it is important to ensure that the source data is stored in a format/datastore which makes querying and modifying the data relatively painless. This decision is largely driven by technological considerations, like:

- Scale of data (centralised/distributed store?)
- Sophistication of queries (OLAP/OLTP?)

- Structure of data, or lack thereof (SQL/NoSQL?)

We were dealing with only about 29000 records, and most of the analysis would probably be performed outside the database. Thus, we opted to use MySQL as our datastore.

3.2.2 Schema

The decisions when creating the database schema affect the ease of querying for relevant information. Apart from the attributes of interest, we wanted to store the individual binary responses as well. One way is to create one column for each response, giving us a total of 112 columns for storing these responses (56 for pre-intervention, 56 for post-intervention). The other way, and that is the one that we chose was to store this information as a 64-bit integer (bigint for MySQL). When required, we could unpack the individual response bits from this number.

A `desc responses;` command on the table reveals the schema we ended up with.

Field	Type	Null	Key	Default	Extra
student_id	int(11)	YES		NULL	
area	char(50)	YES		NULL	
pre_performance	bigint(20)	YES		NULL	
post_performance	bigint(20)	YES		NULL	
language	char(50)	YES		NULL	
gender	char(20)	YES		NULL	
pre_total	int(11)	YES		NULL	
post_total	int(11)	YES		NULL	
id	int(11)	NO	PRI	NULL	auto_increment
school_id	int(11)	YES		NULL	
year	int(11)	YES		NULL	

The most important use of the reference data is to locate the schools geographically. Given that geocoding the school from its name, we used the cluster to locate schools in 2D space. We deal with geographical analysis in a later section. The schema of the master data mostly mirrors the CSV master data file format, with the addition of latitude and longitude, like so:

Field	Type	Null	Key	Default	Extra
district	char(50)	YES		NULL	
block	char(50)	YES		NULL	
cluster	char(50)	YES		NULL	

school_id	int(11)	YES		NULL		
school_code	char(20)	YES		NULL		
school_name	char(50)	YES		NULL		
id	int(11)	NO	PRI	NULL	auto_increment	
latitude	decimal(20,10)	YES		NULL		
longitude	decimal(20,10)	YES		NULL		
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To identify latitude and longitude, we used Google’s Map API to geocode the cluster information. It is to be noted that there may be some clusters which weren’t located by the Map API, and some more work is needed to cross-validate the coordinate information taken from the Map API.

3.3 Data migration: Identifying invalid data

It is natural to expect missing or corrupted data. The most crucial attribute are the score data, as any misinterpretation of that data may adversely bias the quality of our analysis. Thus, specific checks were put in place to ensure that none of the binary responses was null or some string other than 0 or 1.

Using this check, we found 1067 responses which violated it. All of them had either empty pre- or post-intervention scores. We did not migrate these response records, though it may be possible to do Monte Carlo simulations to predict the missing data.

As a result, out of a total of 28535 records in the original source, 27468 were migrated to the database.

We also found a large fraction of records which did not have a LANGUAGE attribute, i.e., that field was empty. Nevertheless, they were included in the migration.

4 Bias

Analysis is most susceptible to bias in the data collection stage. Sampling is one such activity. If, for a statistical study, participating individuals are not equally likely to have been selected, it may be difficult to distinguish between the actual phenomenon and this biased sampling. This sort of bias is called sampling bias.

4.1 Sampling bias

To find evidence for bias, we looked at a few parameters. Here is the breakdown of the population by language, with the biggest language bucket highlighted.

Unspecified=869
URDU=3564
KANNADA=18685
TELUGU=1688
TAMIL=2051
MARATHI=91
OTHER=239
HINDI=243
KONKANI=18
GUJARATHI=12
NOT KNOWN=3
ORIYA=2
MULTI LNG=1
BENGALI=1
NEPALI=1

There is an overwhelming proportion of students who speak Kannada as their mother tongue (leading by an order of magnitude), a fact that is very likely to bias any sort of analysis where language is involved. We must remain cognizant of such biases, and interpret the results accordingly.

Here is the breakdown of the population by gender.

Girl=14822
Boy=12646

There is not a huge disparity between the two sexes, which indicates that any analysis/prediction based on gender may be less biased.

5 Shape of the Data

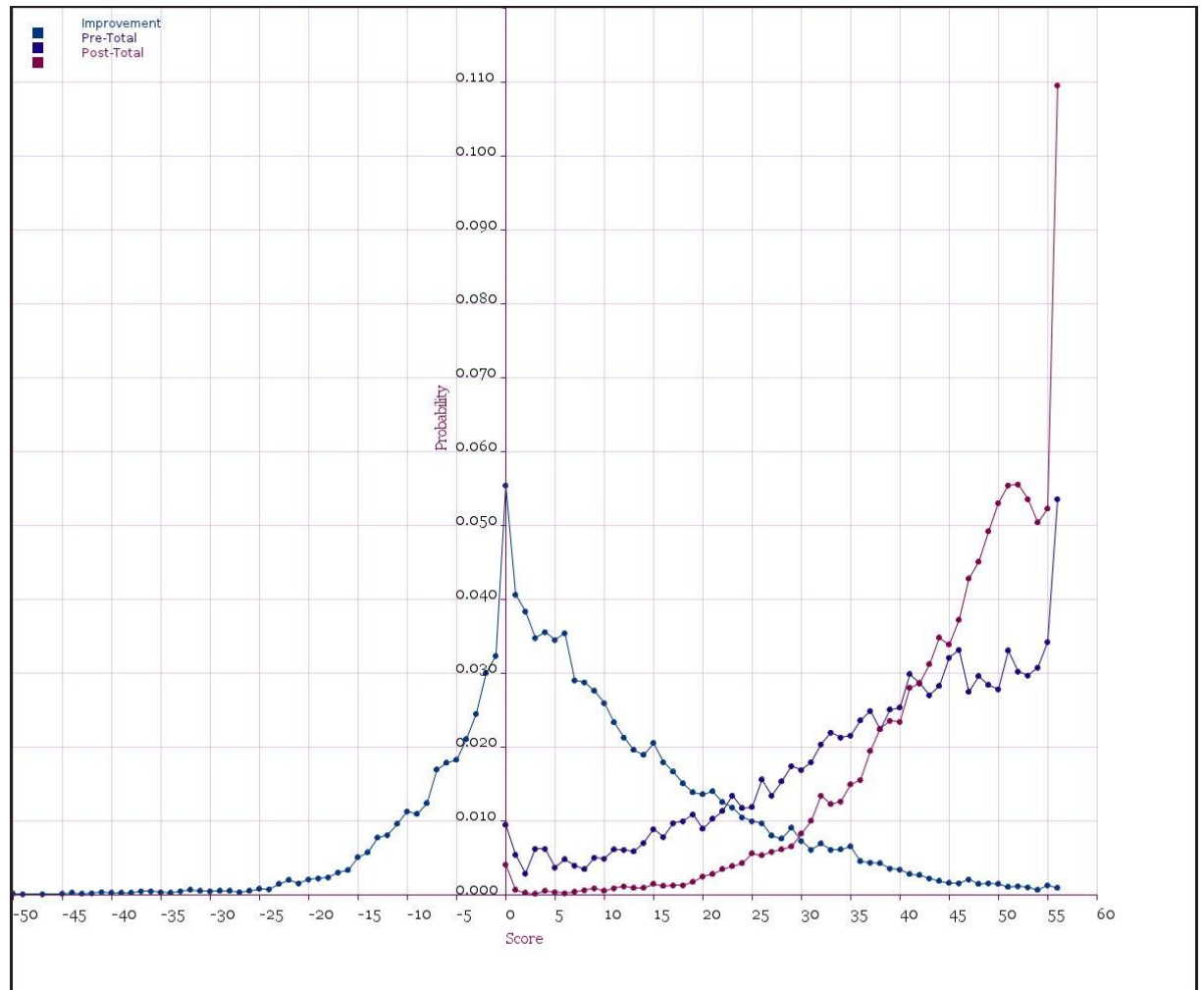
Before embarking on any deep analysis of data, it behooves us to look at the shape of the raw data. There are a few reasons why we want to do this.

- **Evident trends/outliers:** Visualisation of the raw data set is always a quick way to spot trends without doing too much analysis. Of course, visualisation is best suited for 1,2 and 3-dimensional data: data of higher dimensionality must usually be either sliced prior to visualisation, or have its dimensionality reduced, before projecting it onto the 2D plane. Having said that, there are other ways of visualising the data without sacrificing any dimensions at all, such as Parallel Coordinates, though it is more suited to data exploration.
- **Evidence of conformance to well-known distributions:** There exist many probability distributions, some of whose properties are well-studied and well-known, like the Normal distribution. If the data approximates one of these distributions, there are several mature statistical methods which may be applied to test different hypotheses and properties of the data. Indeed, many of the classical statistical analyses make the assumption that the underlying data is normally distributed.

In the following sections, we shall explore the shape of the Anganwadi 2010 dataset, and record our observations on it.

5.1 Univariate distributions

The graph below shows 3 distributions: the pre-intervention scores, the post-intervention scores, and the improvements.



5.1.1 Observations

- The pre-intervention score with the highest number of students is 56, which is the highest score possible. This implies that, even prior to intervention, a sizeable fraction of the students have scored very high.
- The post-intervention score also follows the same trend, albeit with a steeper curve, which implies that many students have scored better in the post-test than in the pre-test.
- The improvement distribution is peaked, the peak being near zero. This makes sense, because if a large fraction of students answered all 56 questions as 1 in the pre-intervention score, there really is no way for them to

improve. This is assuming that their performance did not worsen in the post-test. In fact, the calculated mean is around 7.

- There is a significant fraction of students whose performance has worsened in the post-test. This number is 7081. Out of those, we noticed that the worsening was dramatic for a small set. We have listed down the records which had a regression of 40 or more, below.

student_id	area	pre_total	post_total	language
1506619	VABASANDRA	52	0	KANNADA
1444355	KITTAGANA COLONY	56	0	KANNADA
1426910	PRIYA DARSHINI	53	0	KANNADA
1445387	KYALASANAHALLI	51	1	TELUGU
1445382	KOTHANUR	44	0	TAMIL
1445383	KOTHANUR	41	0	KANNADA
1442911	BETTANA PALYA	55	12	KANNADA
1445160	KODIGEHALLI	52	0	KANNADA
1457095	KAVERI NAGARA	41	0	KANNADA
1457090	KAVERI NAGARA	44	0	TELUGU
1457092	KAVERI NAGARA	41	0	TELUGU
1507686	REHMATH NAGAR	44	0	URDU
1448385	MALSANDRA	50	0	KANNADA
1455798	KANTEERAVA COLONY	55	15	KANNADA
1444466	PRIYA DARSHINI	52	0	KANNADA
1444467	PRIYA DARSHINI	44	0	KANNADA
1445337	RACHENAHALLI	52	0	KANNADA
1425269	VINYAKNAGAR	41	0	KANNADA
552534	KYALASANAHALLI	52	1	TELUGU
1448976	KRISHNA SAGARA COLONY	54	14	KANNADA
1507157	BELTHURU	52	7	KANNADA
1444897	MUNESHWARA NAGAR	45	0	TAMIL
1444890	MUNESHWARA NAGAR	40	0	KANNADA
1542861	VERABADRA NAGAR 1	56	1	KANNADA
1358415	KOTHANUR	48	8	
1445437	THRIVENINAGARA	40	0	TELUGU
1442907	BETTANA PALYA	55	8	KANNADA
1457106	KAVERI NAGARA	40	0	TELUGU
1445444	THRIVENINAGARA	41	0	TELUGU
1444474	PRIYA DARSHINI	54	0	KANNADA
1445159	KODIGEHALLI	41	0	KANNADA
511998	KODIGEHALLI	55	0	KANNADA
1356274	KAVERI NAGARA	56	0	
1358429	KOTHANUR	42	0	
1497510	JALAHALLI 1	42	0	KANNADA

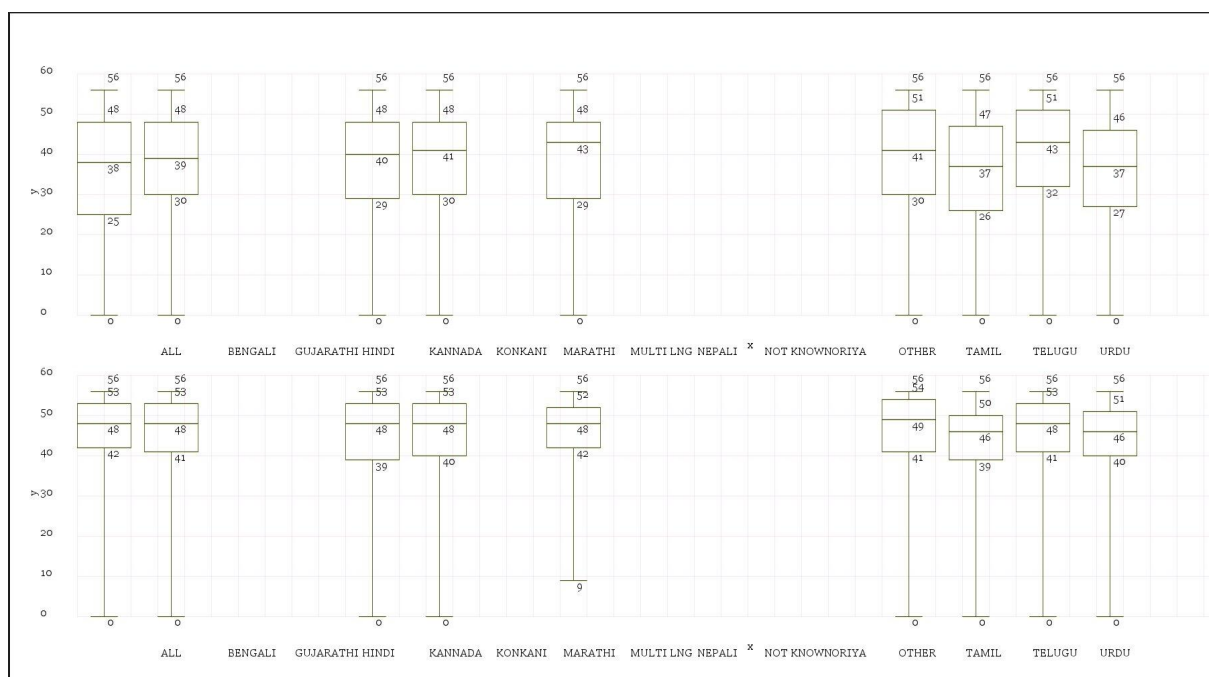
	1443914		BIDARAHALLI		56		12		KANNADA	
	1366955		PRIYA DARSHINI		53		0		KANNADA	
	1366956		PRIYA DARSHINI		53		0		KANNADA	
	1447019		MADAPPANA HALLI		42		0		TELUGU	
	1355112		BYRATHI BANDE		55		14			
	1504259		MAYASANDRA A		56		0		KANNADA	
	1457120		KAVERI NAGARA		43		0		TAMIL	
	1457089		KAVERI NAGARA		43		0		TAMIL	
	1445171		KODIGEHALLI		44		0		KANNADA	
	1457203		SARAIPALYA		51		0		URDU	
	1457179		BYRATHI BANDE		55		14		KANNADA	
	1504538		KEMPEGOWDA NAGAR		51		7		KANNADA	
	1444486		PRIYA DARSHINI		49		0		KANNADA	
	1444488		PRIYA DARSHINI		42		0		KANNADA	
	1451831		AMBED NAGAR		50		9		TAMIL	
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- The post-intervention score distribution seems to follow a power law. We shall consider modeling this attribute in the next section.

5.2 Outlier Analysis

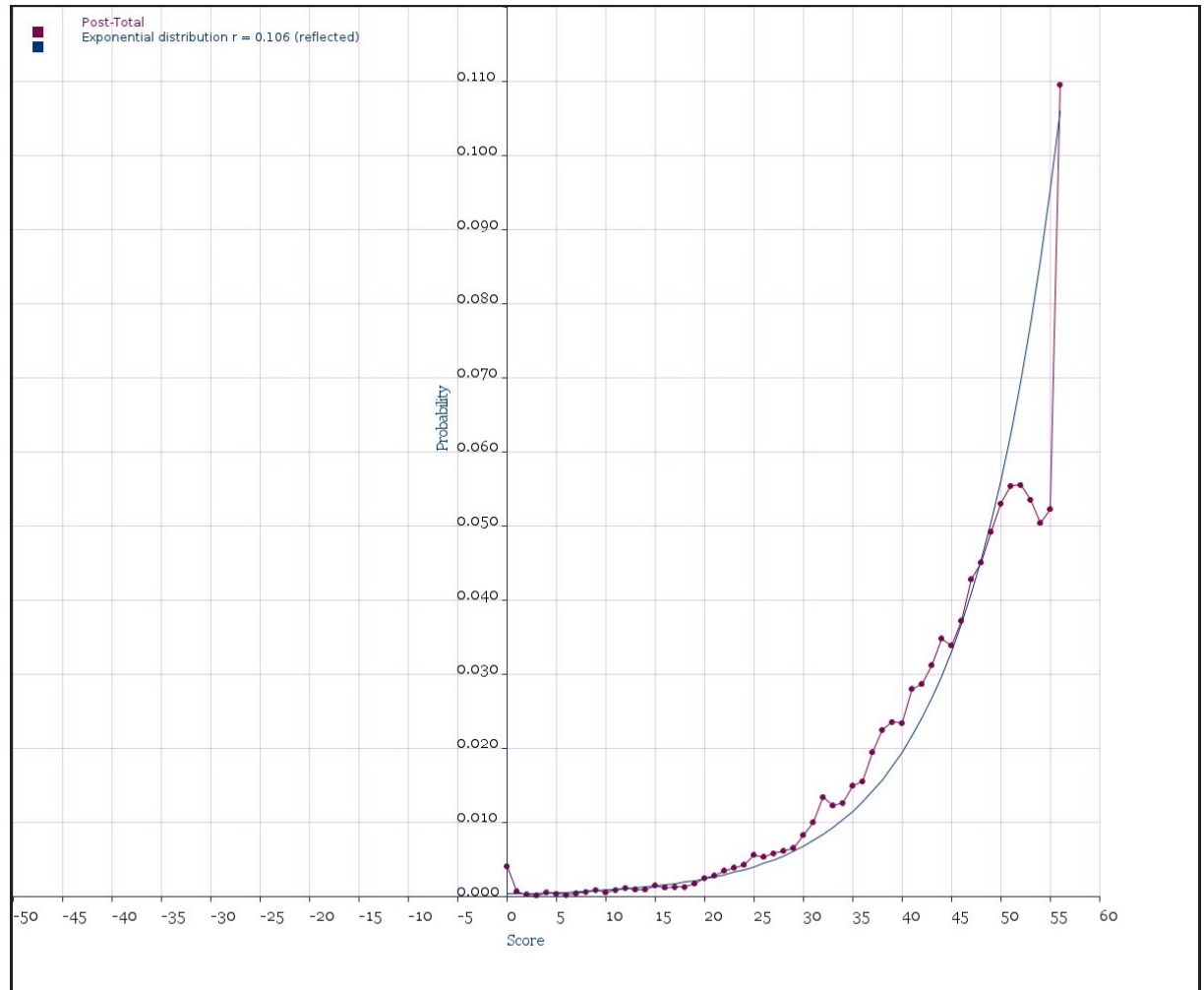
5.3 Bivariate distribution

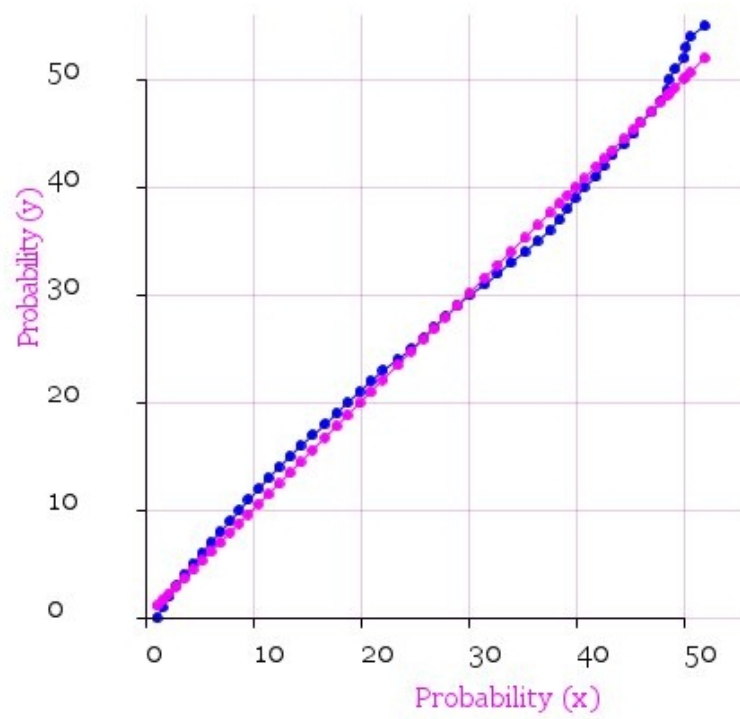
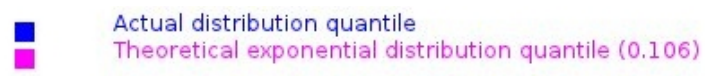
5.4 Summary plots



6 Data exploration

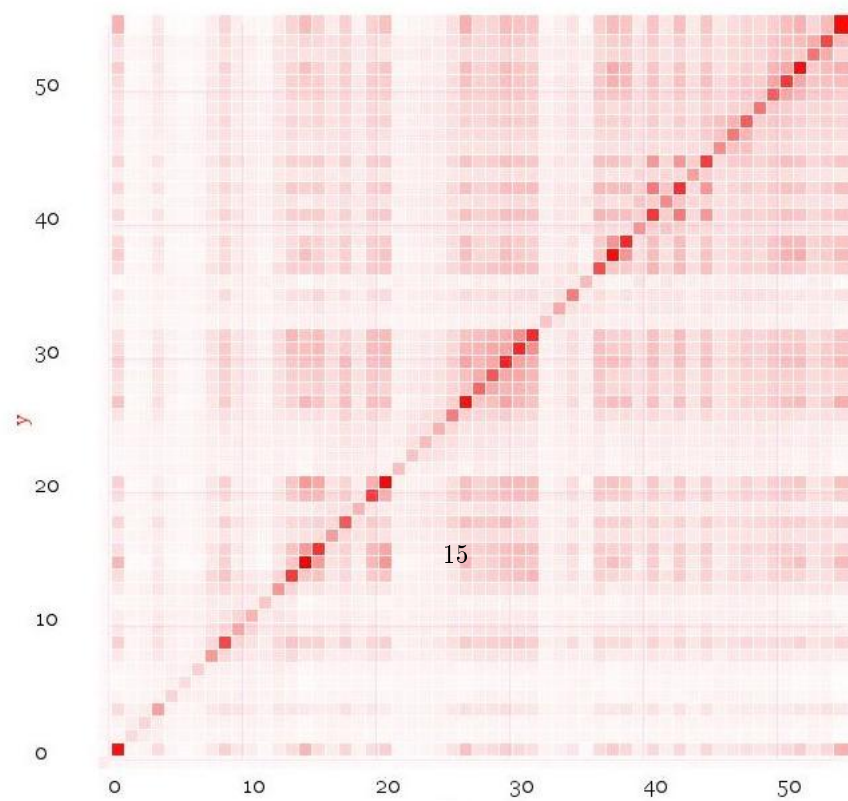
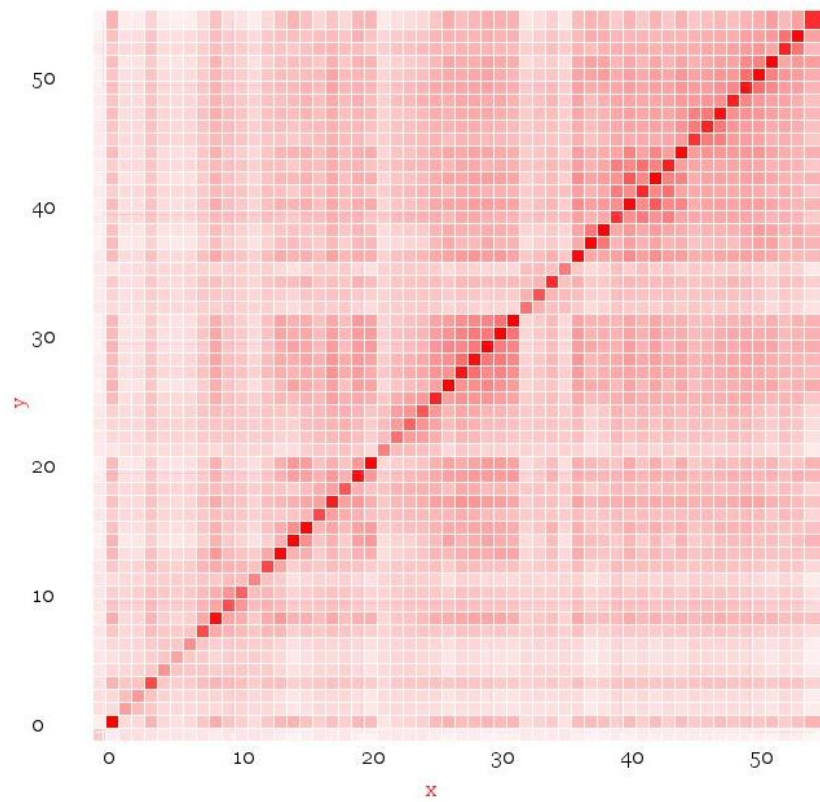
6.1 Modeling the probability distributions





6.2 Parallel Coordinates

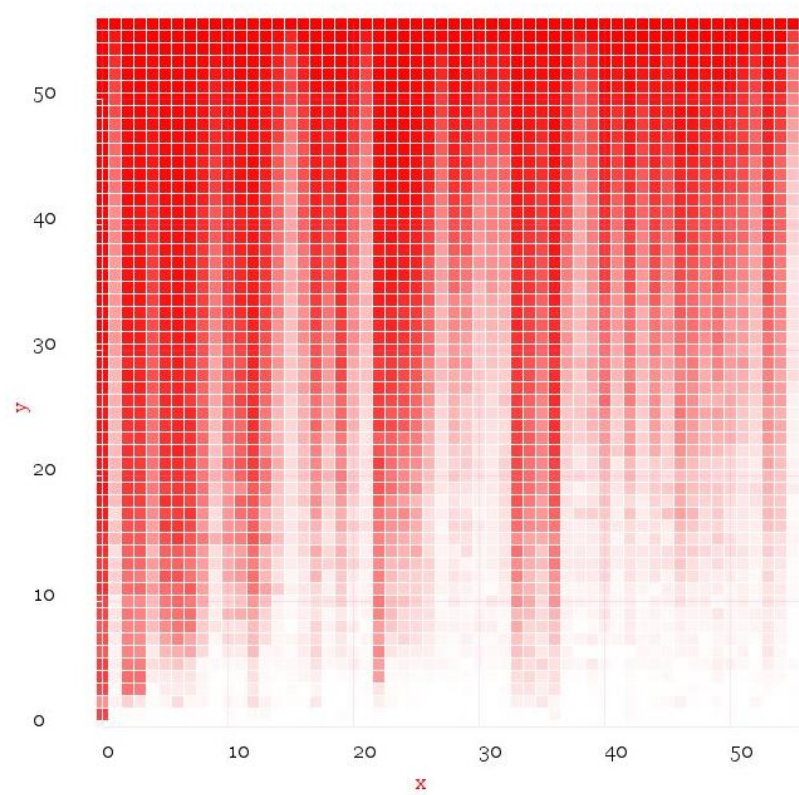
6.3 Covariance plot



6.4 Geographical distribution



6.5 Answer distribution

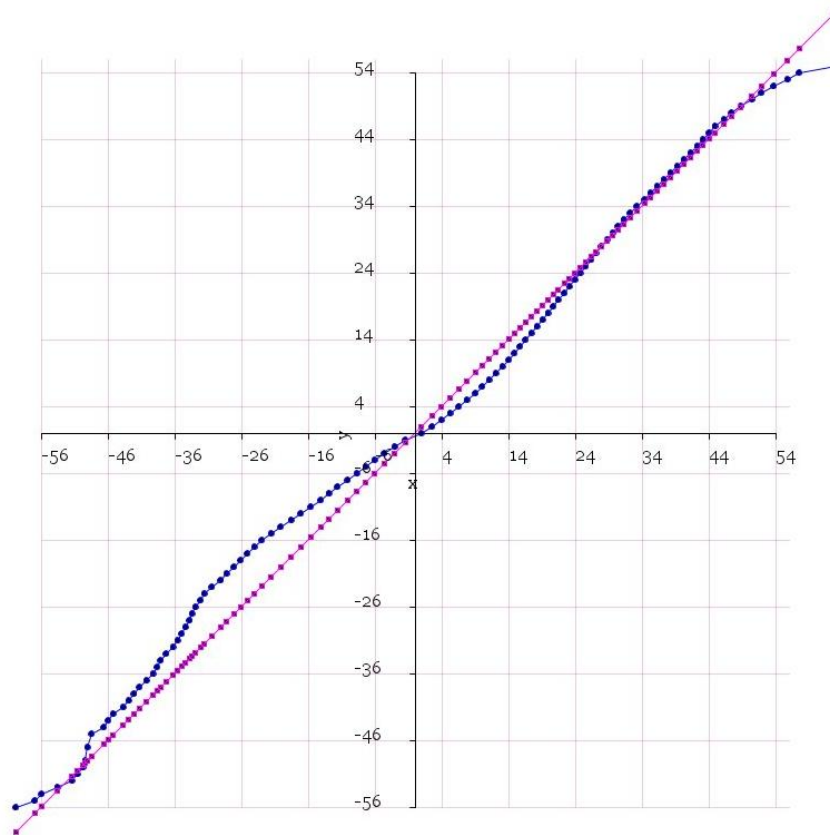


7 Tests for Univariate Normality

7.1 Evidence

7.1.1 Jarque-Bera test

7.1.2 Normal probability plot



7.2 Summary

8 Tests for variable independence

8.1 Chi-square test

Null hypothesis: Area and Improvement are NOT related.

For **area vs. improvement**

Chi-Square statistic = 56499.4692602837

$X^2 = 9652.9739$

Degrees of freedom = 9426

Null hypothesis rejected

^c

Null hypothesis: Area and Pre-Score are NOT related.

For **area vs. pre-score**

Chi-Square statistic = 58665.7089390644

$X^2 = 8062.2959$

Degrees of freedom = 7855

Null hypothesis rejected

Null hypothesis: Area and Post-Score are NOT related.

For **area vs. post-score**

Chi-Square statistic = 38567.0016158761

$X^2 = 8062.2959$

Degrees of freedom = 7855

Null hypothesis rejected

Null hypothesis: Language and Post-Score are NOT related.

For **language vs. post-score**

Chi-Square statistic = 280.234448946825

$X^2 = 96.2166$

Degrees of freedom = 75

Null hypothesis rejected

Null hypothesis: Language and Improvement are NOT related.

For **language vs. improvement**

Chi-Square statistic = 232.464548410971

$X^2 = 113.1452$

Degrees of freedom = 90

Null hypothesis rejected

Null hypothesis: Language and Pre-Score are NOT related.

For **language vs. pre-score**

Chi-Square statistic = 277.85501653079

$X^2 = 96.2166$

Degrees of freedom = 75

Null hypothesis rejected

9 Prediction

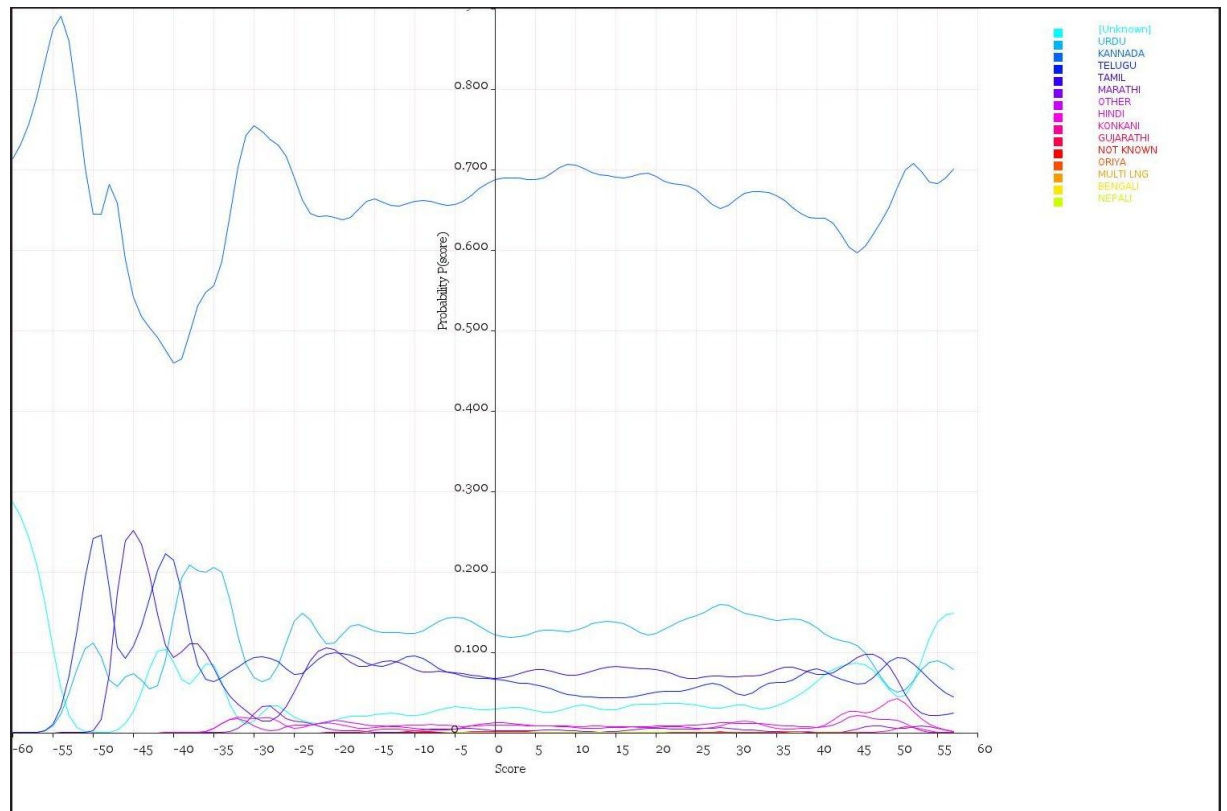
9.1 Decision Trees

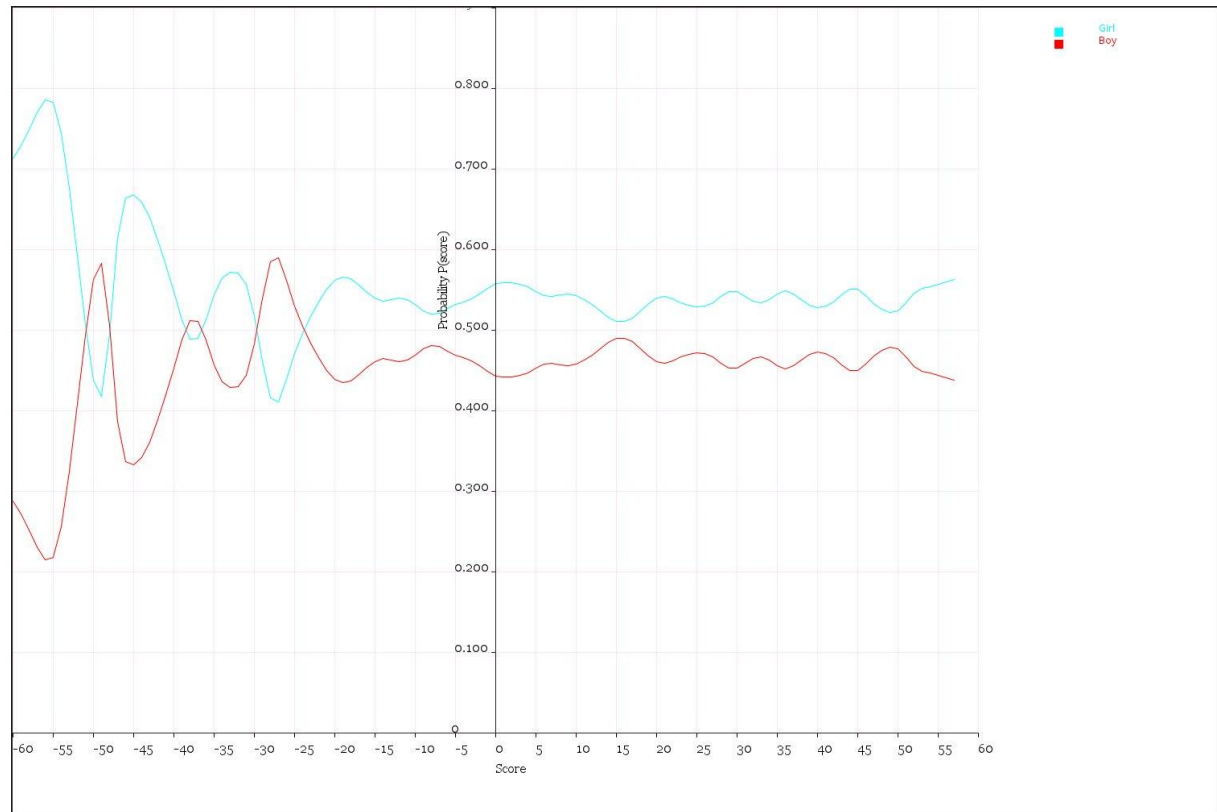
9.2 Bayes classifier

9.3 Density estimators

9.3.1 Naive Bayes density

9.3.2 Kernel density estimation





10 Dimension reduction/Factor analysis

10.1 Principal Component Analysis

11 Technical notes