Practical Work 1: PRISM, A Rule-Based Classifier

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1 Definition of the problem

The aim of the practical is focused on the implementation and validation a rule-based classifier, for this particular work we considered PRISM algorithm. In short we are going to mention some of the PRISM algorithm specifications:

- Non-ordered Procedure
- Non-incremental Learning Style
- Selector-based Algorithmics
- Building Mechanism Genral-Especific
- 100 % Precsion on Rules Knowledge Base

PRISM a rule-based algorithm models the data in form of a set of rules for classification purposes accept numeric values (integers) and categorical values. Hence, in this implementation whenever we have to deal with numeric continuous values we considered a module that cast values into integers to treat them as numeric categories, furthermore the PRISM modules developed consider the missing data in attributes treatment as part of the cleansing of the data and preprocesing.

2 Algorithm Implementation in Python with Pandas

```
%Data Preprocessing Function

    X_train = [];
    X_test = [];
    y_train = [];
    y_test = [];

    n_samples = 0;
    n_features = 0;

    csv_datasets = ["./Data/contact_lenses.csv",
                    "./Data/restaurant_costumer_rating_feats.csv",
                    "./Data/mushrooms.csv",
                    "./Data/2015_happiness_report_mod.csv",
                    "./Data/biomechanical_orthopedic_feats.csv"];

    csv_datasets_col_names = [['age','visual_deficiency','astigmatism','production','lents'],
```

```
                       ['user_id', 'place_id', 'rating','food_rating','service_rating'],
                       ['class','cap_shape','cap_surface','cap_color','bruises','odor',
                        'gill_attachment','gill_spacing','gill_size','gill_color','stalk_shape',
                        'stalk_root','stalk_surface_above_ring','stalk_surface_below_ring',
                        'stalk_color_above_ring','stalk_color_below_ring','veil_type','veil_color',
                        'ring_number','ring_type','spore_print_color','population','habitat'],
                       ['country','region','happiness_rank','happiness_score','standard_error',
                        'economy_gdp','family','health_life_expectancy','freedom','trust_gov_corrupt
                        'generosity','dystopia_residual'],
                       ['pelvic_incidence', 'pelvic_tilt', 'lumbar_lordosis_angle',
                        'sacral_slope','pelvic_radius','spondylolisthesis_degree','diagnostic'],
                       ];


def repair_continuous_attributes(self, dataset, features):

    self.n_samples = dataset.shape[0];
    self.n_features = dataset.shape[1] - 1;

    for feat in features:
        if dataset[feat].dtype == np.float64:
            dataset[feat] = dataset[feat].astype(int);



def csv_processor(self, csv_path, feature_names):

    dataset = pd.read_csv(csv_path);
    dataset.columns = feature_names;
    return dataset;


def fix_dataset_missing_values(self,dataset):

    for column in dataset.columns:

        dataset[column] = dataset[column].replace('?',np.NaN);
        dataset[column] = dataset[column].fillna(dataset[column].value_counts().index[0]);



def build_learning_sets(self,dataset,class_attr,train_size):

    dataset = dataset.sample(frac=1).reset_index(drop=True);
    n_train = int(self.n_samples*train_size);
    n_test = self.n_samples - n_train;

    dataset_ = dataset.copy(deep=True);
    self.fix_dataset_missing_values(dataset_);

    print(dataset_);

    self.y_train = dataset_.ix[0:n_train,class_attr].copy(deep=True);
```

```
        self.y_test = dataset_.ix[n_train+1:self.n_samples,class_attr].copy(deep=True);

        dataset_ = dataset_.drop(class_attr,1);

        self.X_train = dataset_.ix[0:n_train].copy(deep=True);
        self.X_test = dataset_.ix[n_train+1:self.n_samples].copy(deep=True);



    def display_data_info(self, dataset):

        print("\n1. Number of samples: " + str(self.n_samples));
        print("\n2. Number of features: " + str(self.n_features));
        print("\n3. Feature types:");
        print(dataset.dtypes);
        print("\n4. Data:");
        print(dataset);
        print("\n5. Training sets:");
        print(self.X_train);
        print(self.y_train);
        print("\n6. Testing sets:");
        print(self.X_test);
        print(self.y_test);


    def data_preprocessing(self):

        print('A) ::Processing CSV files::');
        dataset = self.csv_processor(self.csv_datasets[0],self.csv_datasets_col_names[0]);

        print('B) ::Repairing continuous attributes in Dataset::');
        self.repair_continuous_attributes(dataset,dataset.columns);

        print('C) ::Building train/test sets::');
        self.build_learning_sets(dataset,dataset.columns[-1],1.0);

        print('D) ::Dataset Information::');
        #self.display_data_info(dataset);



%PRISM Algorithm

 def PRISM(self):


        print("\n::: DATASET X,Y:::");
        print(self.X_train);
        print(self.y_train);



        print("\n:::PRISM Algorithm:::");
```

```
prism_rule_set = [];
for label in set(self.y_train):

    print("<<<<<<<<< CURRENT LABEL: "+str(label)+">>>>>>>>>>");

    instances = [i for i, val in enumerate(self.y_train) if val == label];

    while instances:
        rule = [];
        X_train_ = self.X_train.copy(deep=True);
        instances_covered = [];
        perfect_rule = False;

        print(" ******** WHILE PERFECT RULE? ********* ");
        print("\n");

        rule_precision = 0.0;
        rule_coverage = 0.0;

        while perfect_rule == False and len(rule) < self.n_features+1:
            optimal_selector = [("","")];
            optimal_selector_prec = [0.0,0.0,0.0];
            instances_covered = [];

            print("^^^^^^^^ INSTANCES TO FIT ^^^^^^^^^");
            print(instances);
            print("\n");


            print(" %%%%%%%% PREVIOUS OPT SELECTOR %%%%%%% ");
            print(optimal_selector);
            print(optimal_selector_prec);
            print("\n");


            for attribute in X_train_.columns:
                attr_column = X_train_.loc[:,attribute];

                for attr_value in set(attr_column):

                    total_attr_values_instances = attr_column[(attr_column == attr_value)].index.g
                    total_matches = len(total_attr_values_instances);
                    print("::::TOTALS::: size = "+str(total_matches));
                    #print(total_attr_values_instances);


                    positive_attr_values_instances = list(set(total_attr_values_instances) & set(i
                    positive_matches = len(positive_attr_values_instances);
                    print("::::POSITIVES::: size = "+str(positive_matches));
                    #print(positive_attr_values_instances);

                    #Computing Precision of the rule (by considering a filtered dataset instances
                    precision = (1.0 * positive_matches) / total_matches;
```

```
            #Computing Coverage of the rule (considering all the instances coverd by the r
            coverage = (1.0 * positive_matches) / self.n_samples;



            if precision > optimal_selector_prec[2]:
                optimal_selector = (attribute,attr_value);
                optimal_selector_prec[0] = positive_matches;
                optimal_selector_prec[1] = total_matches;
                optimal_selector_prec[2] = precision;
                rule_precision = precision;
                rule_coverage = coverage;
                instances_covered = positive_attr_values_instances;

            elif precision == optimal_selector_prec[2] and positive_matches > optimal_sele
                optimal_selector = (attribute, attr_value);
                optimal_selector_prec[0] = positive_matches;
                optimal_selector_prec[1] = total_matches;
                optimal_selector_prec[2] = precision;
                instances_covered = positive_attr_values_instances;
                rule_precision = precision;
                rule_coverage = coverage;

    print(" %%%%%%%% UPDATED OPT SELECTOR ? %%%%%%% ");
    print(optimal_selector);
    print(optimal_selector_prec);
    print("\n");



    if optimal_selector_prec[2] > 0.0 and optimal_selector_prec[2] < 1.0:

        print(" ***** AFTER CHECK ALL ATTR-VALS PAIRS MY RULE IS NOT PERFECT BUT (PREC > 0

        print(X_train_);
        print(X_train_.index.get_values());

        rule.append(optimal_selector);
        selector = rule[-1]

        print("FILTER SELECTOR::");
        print(selector);

        print("ACCESSING TO SELECTOR ATTR TO OBTAIN FILTER INDEXES:::");
        filtered_rows = X_train_[(X_train_[selector[0]] != selector[1])].index.get_values(
        print(filtered_rows);

        print("FILTERING DATASET BY CUMULATIVE RULE OF SELECTORS::");

        X_train_ = X_train_.drop(filtered_rows).copy(deep=True);
        X_train_ = X_train_.drop(selector[0], 1);

        print("IF THERE ARE NO MORE ATTRIBUTES TO COMPOSE THE RULE:::");
```

```
                if len(X_train_.columns) == 0:
                    perfect_rule = True;
                    continue;

                print(" %%%%%%%%%% X_train_ FILTERED BY CURRENT COMPOSED RULE %%%%%%%%%%%");
                print(X_train_);
                print("\n");


            elif optimal_selector_prec[2] == 1.0:

                print(" ***** AFTER CHECK ALL ATTR-VALS PAIRS MY RULE IS PERFECT!!! ***** ");
                rule.append(optimal_selector);
                perfect_rule = True;
                continue;

            elif optimal_selector_prec[2] == 0.0:
                raw_input("....... UNSUAL CASE .......");



        print("^^^^^^^^^ INSTANCES COVERED ^^^^^^^^^^");
        print(instances_covered);
        print("\n");

        instances = list(set(instances) - set(instances_covered));

        print("^^^^^^^^^ INSTANCES REMAINING ^^^^^^^^^^");
        print(instances);

        rule.append(label);
        rule.append([rule_precision,rule_coverage]);

        print("++++++++ RULE FOUND +++++++++");
        metrics = rule[-1];

        print("Rule:");
        print(rule);
        print("Rule-Precision: "+metrics[0]);
        print("Rule-Coverage: "+metrics[1]);
        print("\n");

        prism_rule_set.append(rule);

    return prism_rule_set;
```

3 Technical Aspects in Algorithm Implementation

The tecnical specifications comprise placing the Data folder into the Source folder, sinces the paths of the csv files in the Python code are relative to the Source folder of the code. In addition, the PRISM algorithm has to be called by creating an object of the class *RuleBasedClassifiers*, performing pre-processing on the data by *data_preprocessing* function, and finally by running *PRISM* function, and printing the ruleset retrieved by the PRISM Learning as we can see in the Python example below:

```
RBC = RuleBasedClassifiers();

RBC.data_preprocessing();
rule_set = RBC.PRISM();

print("%%%% FINAL PRISM RULE SET %%%%");
print("\n");
for prism_rule in rule_set:
    print(prism_rule);
```

4 Datasets

4.1 Lenses Dataset

Dataset related to classifying the lenses for different types of people according to human-eye and human features, it was taken from the slides of SEL course, and comprises: 24 instances and 5 attributes (age, visual deficiency, astigmatism, production, lents) all of them categorical.

4.2 Restaurant Raitings in USA Dataset

Dataset related to classifying the service rating of different people rating different places and considering different types of rating as features, it was taken from UCI-Keagle colaborators, and comprises: 1162 instances and 5 attributes (user id, place id, rating, food rating, service rating) mixed attributes categorical, integer numeric.

4.3 Biomechanical Orthopedic Dataset

Dataset related to classifying the diagnostic of the patients that have orthopedic issues with different body measures considered as features, it was taken from UCI-Keagle colaborators, and comprises: 310 instances and 7 attributes (pelvic incidence, pelvic tilt, lumbar lordosis angle, sacral slope, pelvic radius, spondylolisthesis degree, diagnostic) mixed attributes categorical, integer numeric.

4.4 Poisoned-Infected Mushrooms Dataset

Dataset related to classifying the poisoned and infected mushrooms according to different mushroom internal quemical-color features considering different types of mushrooms, it was taken from UCI-Keagle colaborators, and comprises: 8124 instances and 24 attributes (class, cap shape, cap surface, cap color, bruises, odor, gill attachment, gill spacing, gill size, gill color, stalk surface below ring, stalk color above ring, stalk color below ring, veil type, veil color, ring number, ring type, spore print color, population, habitat, etc.) mixed attributes categorical, integer numeric.

4.5 Happiness Report Modified Dataset

Dataset related to classifying the happines score from people of different countries considering their socioeconomic characterstics, self life perspectives, and personal preferences, it was taken from UCI-Keagle colaborators, and comprises: 158 instances and 12 attributes (country, region, happiness rank, happiness score, standard error, economy gdp, family, health life expectancy, freedom, trust gov corruption, generosity, dystopia residual) mixed attributes categorical, integer numeric.

5 Ruleset's Precision & Coverage

In this section we are going to overviewed the different rulesets found by prism, each list comprise a rule, where each pair of values in parenthesis represent the selectors that compose the rule, the single categorical value the conlcuding class, and the list of two values, represent the precision and the coverage respectively.

5.1 Lenses Dataset

```
[('production', 'reduida'), 'cap', [1.0, 0.5]]
[('production', 'normal'), ('age', 'prebiopic'), ('visual_deficiency', 'hipermetrope'), ('astigmatism',
[('production', 'normal'), ('age', 'preprebiopic'), ('visual_deficiency', 'hipermetrope'), ('astigmatism
[('age', 'prebiopic'), ('visual_deficiency', 'miope'), ('astigmatism', 'no'), ('production', 'normal'),
[('astigmatism', 'si'), ('production', 'normal'), ('visual_deficiency', 'miope'), 'dures', [1.0, 0.125]
[('age', 'jove'), ('visual_deficiency', 'hipermetrope'), ('astigmatism', 'si'), ('production', 'normal')
[('astigmatism', 'no'), ('production', 'normal'), ('visual_deficiency', 'hipermetrope'), 'toves', [1.0,
[('visual_deficiency', 'miope'), ('astigmatism', 'no'), ('production', 'normal'), ('age', 'preprebiopic'
[('age', 'jove'), ('visual_deficiency', 'miope'), ('astigmatism', 'no'), ('production', 'normal'), 'tove
```

5.2 Restaurant Raitings in USA Dataset

```
[('user_id', 'U1135'), 0, [1.0, 0.012058570198105082]]
[('user_id', 'U1073'), 0, [1.0, 0.009474590869939707]]
[('user_id', 'U1128'), 0, [1.0, 0.009474590869939707]]
[('user_id', 'U1019'), 0, [1.0, 0.007751937984496124]]
[('user_id', 'U1069'), 0, [1.0, 0.007751937984496124]]
[('user_id', 'U1062'), 0, [1.0, 0.007751937984496124]]
[('user_id', 'U1049'), 0, [1.0, 0.007751937984496124]]
[('user_id', 'U1105'), 0, [1.0, 0.0068906115417743325]]
[('user_id', 'U1118'), 0, [1.0, 0.006029285099052541]]
[('user_id', 'U1047'), 0, [1.0, 0.002583979328165375]]
[('user_id', 'U1031'), 0, [1.0, 0.002583979328165375]]
[('user_id', 'U1082'), ('rating', 0), 0, [1.0, 0.0068906115417743325]]
[('user_id', 'U1094'), ('food_rating', 0), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1050'), ('food_rating', 0), 0, [1.0, 0.002583979328165375]]
[('user_id', 'U1114'), ('rating', 0), 0, [1.0, 0.007751937984496124]]
[('user_id', 'U1023'), ('rating', 0), 0, [1.0, 0.002583979328165375]]
[('user_id', 'U1130'), ('rating', 0), 0, [1.0, 0.002583979328165375]]
[('user_id', 'U1032'), ('rating', 0), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1092'), ('food_rating', 0), 0, [1.0, 0.003445305770887166 2]]
[('user_id', 'U1030'), ('rating', 0), 0, [1.0, 0.004306632213608958]]
[('user_id', 'U1094'), ('place_id', 135057), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1102'), ('place_id', 132858), 0, [1.0, 0.0008613264427217916]]
[('place_id', 132870), ('food_rating', 2), 0, [1.0, 0.0017226528854435831]]
[('place_id', 132885), ('rating', 0), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1111'), ('food_rating', 0), 0, [1.0, 0.003445305770887166 2]]
[('user_id', 'U1057'), ('place_id', 135046), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1112'), ('place_id', 132834), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1032'), ('rating', 2), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1113'), ('rating', 0), 0, [1.0, 0.002583979328165375]]
[('user_id', 'U1094'), ('place_id', 135070), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1068'), ('rating', 0), 0, [1.0, 0.002583979328165375]]
[('user_id', 'U1034'), ('rating', 0), 0, [1.0, 0.002583979328165375]]
[('user_id', 'U1072'), ('rating', 0), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1129'), ('place_id', 132665), 0, [1.0, 0.0008613264427217916]]
[('place_id', 132654), ('user_id', 'U1129'), 0, [1.0, 0.0008613264427217916]]
[('place_id', 135040), ('user_id', 'U1126'), 0, [1.0, 0.0008613264427217916]]
[('place_id', 132560), ('user_id', 'U1067'), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1112'), ('place_id', 135046), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1057'), ('place_id', 135080), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1037'), ('food_rating', 0), 0, [1.0, 0.003445305770887166 2]]
[('user_id', 'U1007'), ('place_id', 135085), 0, [1.0, 0.0008613264427217916]]
```

```
[('place_id', 135021), ('rating', 0), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1050'), ('food_rating', 2), 0, [1.0, 0.002583979328165375]]
[('place_id', 135104), ('rating', 0), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1024'), ('place_id', 135073), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1013'), ('place_id', 135076), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1026'), ('rating', 0), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1106'), ('rating', 0), 0, [1.0, 0.004306632213608958]]
[('user_id', 'U1112'), ('place_id', 135079), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1010'), ('rating', 0), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1094'), ('place_id', 135069), 0, [1.0, 0.0008613264427217916]]
[('place_id', 135050), ('rating', 0), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1057'), ('place_id', 132862), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1024'), ('place_id', 135045), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1133'), ('place_id', 135019), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1007'), ('place_id', 135086), 0, [1.0, 0.0008613264427217916]]
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[('place_id', 135071), ('rating', 0), 0, [1.0, 0.002583979328165375]]
[('place_id', 135048), ('rating', 0), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1070'), ('place_id', 132613), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1011'), ('place_id', 132715), 0, [1.0, 0.0008613264427217916]]
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[('user_id', 'U1029'), ('rating', 0), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1032'), ('place_id', 132834), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1013'), ('place_id', 135085), 0, [1.0, 0.0008613264427217916]]
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[('place_id', 135064), ('user_id', 'U1003'), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1112'), ('place_id', 135047), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1007'), ('place_id', 135032), 0, [1.0, 0.0008613264427217916]]
[('place_id', 132954), ('user_id', 'U1057'), 0, [1.0, 0.0008613264427217916]]
[('place_id', 135021), ('user_id', 'U1100'), 0, [1.0, 0.0008613264427217916]]
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[('place_id', 135065), ('user_id', 'U1036'), 0, [1.0, 0.0008613264427217916]]
[('place_id', 135082), ('user_id', 'U1014'), 0, [1.0, 0.0008613264427217916]]
[('place_id', 135038), ('user_id', 'U1024'), 0, [1.0, 0.0008613264427217916]]
[('place_id', 132572), ('user_id', 'U1013'), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1045'), ('rating', 0), 0, [1.0, 0.0017226528854435831]]
```

```
[('user_id', 'U1058'), ('place_id', 135050), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1059'), ('place_id', 135064), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1101'), ('rating', 0), 0, [1.0, 0.0017226528854435831]]
[('user_id', 'U1132'), ('place_id', 135051), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1032'), ('place_id', 132856), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1126'), ('place_id', 132830), 0, [1.0, 0.0008613264427217916]]
[('user_id', 'U1002'), ('place_id', 135041), 0, [1.0, 0.0008613264427217916]]
[('place_id', 135086), ('user_id', 'U1112'), 0, [1.0, 0.0008613264427217916]]
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5.3 Biomechanical Orthopedic Dataset

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5.4 Poisoned-Infected Mushrooms Dataset

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5.5 Happiness Report Modified Dataset

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6 Conclusions

In particular, this algorithm select mainly rules with the higher precison (tending to 1) relying on attributes in which either the domain of the values in the attribute tend to the number of instances in Training set, or the attribute values tend to the number of classes and having a similar data distribution, this two scenarios allow PRISM to generate simple rules comprising one selector (attribute,value)->class. In addition, for the instances that not follow the two previously mentioned scenarios, the algorithm find complex rules where the number of selector is higher than one. Though the algorithm has a similar behavior compared to ID3 Tree Classification Algorithm at the aspect of Rule Buidling considering rules of attributes with higher domain of values.