A Case Study on Recommending Software Components using Collaborative Filtering

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Introduction

- Software Reuse is increasingly important to enterprises as they invest in developing and maintaining large software systems.
- Reusing software components can help develop better, faster and cheaper software systems [Griss, 1998].

Software Reuse Challenges

- Developers are not always eager to learn reusable component – *The Productivity Paradox*.
- Even if a developer is willing to reuse a component they may not be able to locate it in the component repository.
- As the repository of components grows, it is difficult to remain conversant with all components. Component access needs to be complemented with component delivery.

Motivation

- Traditional methods for component search and retrieval can be classified into four categories [Mili *et al.*, 1998]:

  1. *Keyword Search*
  2. *Faceted Classification*
  3. *Signature Matching*
  4. *Behavioral Matching*

- *Semantic-Based Method Retrieval* [Sugurmaran *et al.*, 2003]: Requirements are specified using natural languages.

If a developer believes a reusable component for a particular task does not exist then they are unlikely to query the component repository. Component delivery is required.

Related Work

- *CodeBroker* [Fischer *et al*., 2002]: Infers the need for a component (method) based on developer comments and method signature. Relies heavily on the components in the repository being correctly commented and the developer actively commented his/her code.

- [Ohsugi *et al*., 2002] propose a system for recommending useful functions, to a standard user, in application software such as MS Word which is based on collaborative filtering.

Our Technique

- A Recommender System based on *Collaborative Filtering*.
- A set of candidate software components (methods) which are likely to be useful to this individual developer are recommended.
- The system allows developers discover reusable software components in a *Learn On Demand* Fashion.

Collaborative Filtering (CF)

- CF systems are founded on the belief that users can be clustered. Users in a cluster share preferences and dislikes for particular items and are likely to agree on future items.

- The goal of CF algorithms is to suggest new items or to predict the utility of a certain item for a particular user based on the user's previous likings and the opinions of like minded users[Sarwar *et al*., 2001].

- A User refers to a Java class and an Item refers to a software component.

Collaborative Filtering (CF)

Active User

Class A

```
classA{
 void method1(){
   Button b;
   b.setText("Button");
   b.setAlignmentX(10);
   b.setAlignmentY(10);
 }
}
```

Class B

```
classB{
 void method1(){
   JMenu m = new JMenu();
   m.setAlignmentX(10);
   m.setAlignmentY(20);
   m.setToolTipText("TT");
 }
}
```

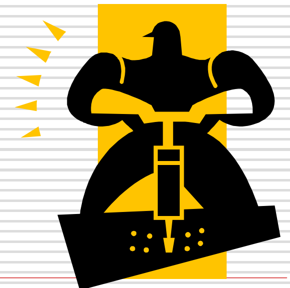
Class C

```
classC{
 void method1(){
   Button b;
   b.setText("Button");
   b.setAlignmentX(10);
   .... ?
 }
}
```

Recommendations for the active user, Class C, are based on the existing items used in class C **and** items used by similar users.

Data Mining

- We need to collect information about user preferences before we can create user clusters.
- Software repositories contain a wealth of valuable information. Usage of software components can be automatically extracted from these repositories of Java classes.
- This information can be used to establish similarities between users.



Repositories Used

- Repositories of open-source Java code, available from *SourceForge* were mined.
- This consisted of over 40 GUI Swing applications including the following:

JHome	*JAdmin*	*TimeTrack*	*Pooka*
Vex	*LumberMill*	*ChordCast*	*JSurfer*
JEdit	*JasperEdit*	*JIV*	*MDateSelecter*

User Similarity

- Users (Java classes) can be clustered by examining the software components they use.
- Each user is treated as vector; the vector holds a count for all components that the user can invoke.

	Method 1	Method 2	Method 3	Method 4	Method 5	Method 6	Method 7	Method 8
User A	0	2	1	0	5	1	0	0

- Similarity between two users can be computed by determining the cosine of the angle formed by their vectors. The cosine will fall in the range [-1,1].

Recommendations

1. Establish the components used by the active user.

2. Find the similarity between each user and the active user. Using the *k*-Nearest Neighbour algorithm, develop a set of the most similar users, i.e. the active users closest neighbours.

3. Produce a recommendation set based on the active users neighbours. The closer a neighbour is to the active user, the more influence it has on the recommendation set.

System Evaluation

- Experiments were carried out on 343 Java classes from over 40 GUI applications.
- A set of candidate Swing components was recommended for each class at various stages of development.

System Evaluation

Original Class

Class A

66% components known

```
        Button b;
        b.setText("Button");
        b.setAlignmentX(10);
        b.setAlignmentY(10);
    }
}
```

(b.setAlignmentY(10); is struck through)

Remove & Recommend

Class A

33% components known

```
        Button b;
        b.setText("Button");
        b.setAlignmentX(10);
        Get Neighbours
        Recommendations
    }
}
```

(b.setAlignmentX(10); is struck through)

Remove & Recommend

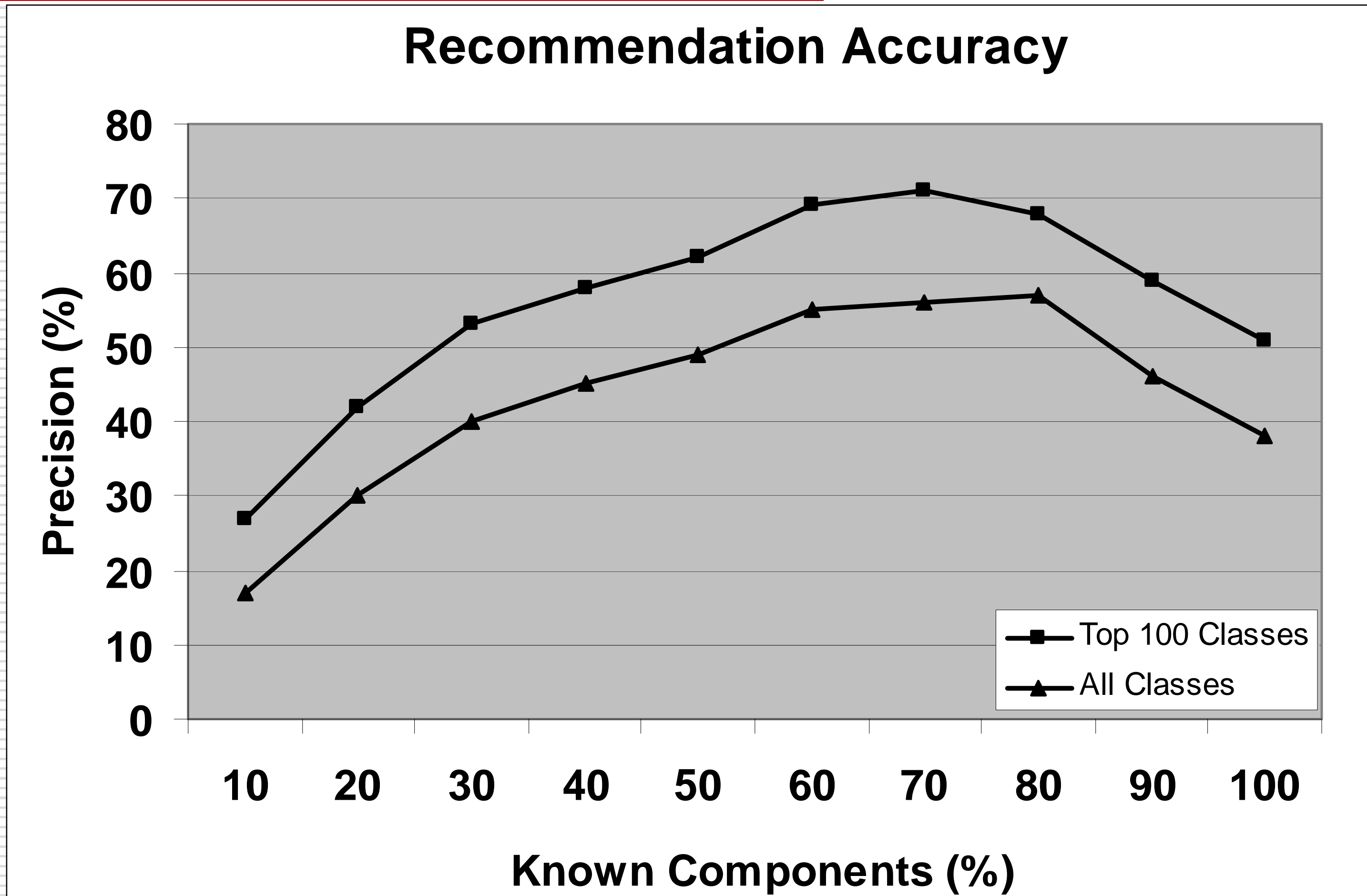
Class A

```
classA{
    void method1(){
        Button b;
        b.setText("Button");
        Get Neighbours
        Recommendations
    }
}
```

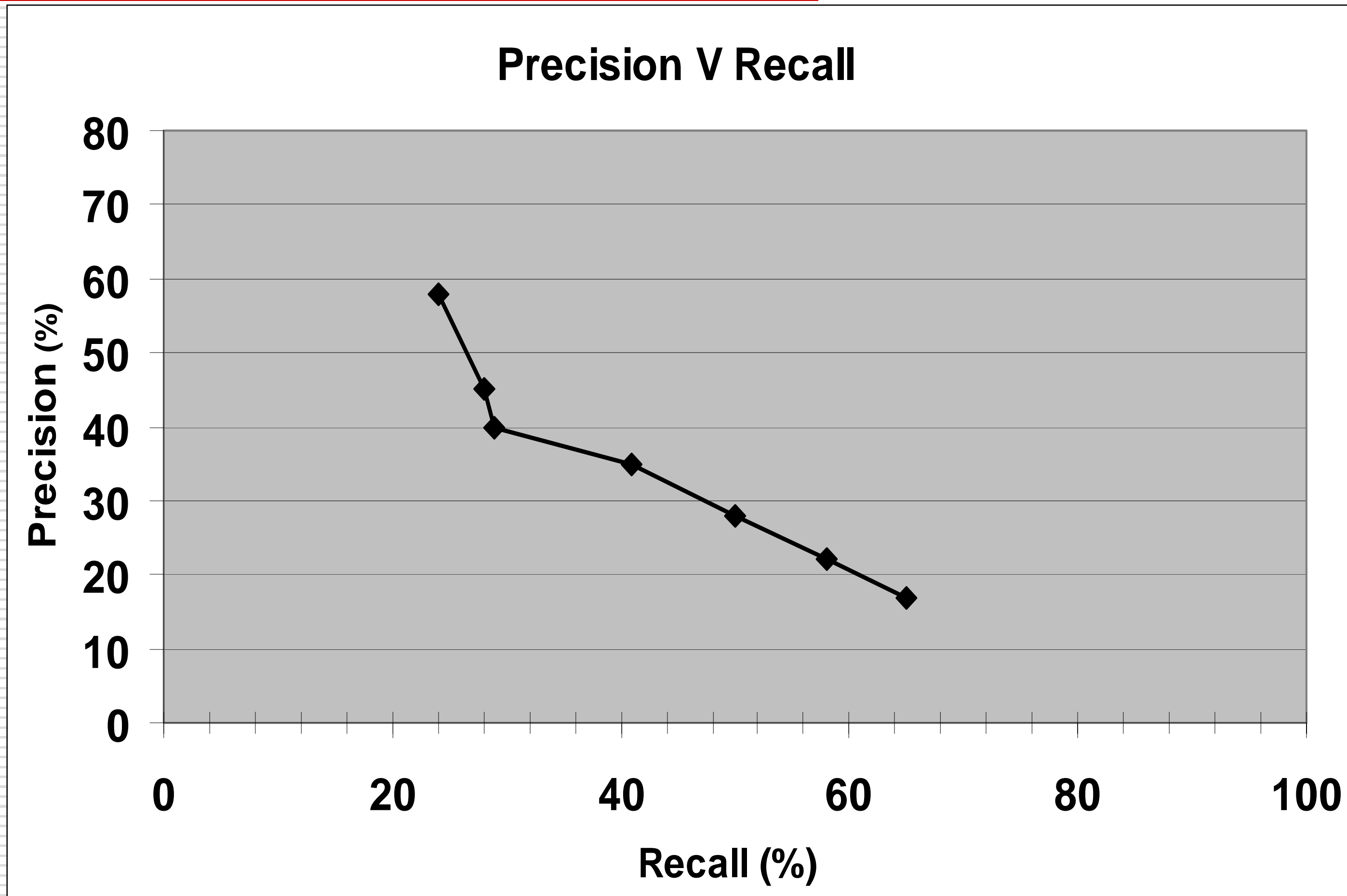
System Evaluation

- Precision and Recall are the most popular metrics for evaluating information retrieval systems.
- *Precision*: The ratio of relevant recommended items to the total number of recommended items.
- *Recall*: The ratio of relevant items selected to the total number of relevant items.
- Usually a trade-off between two.

Results



Results



Results

- The recommender system provides promising results.
- Based on top 100 classes; recommendation precision was over 40% when a developer had utilised between 10% and 20% of the total components they would actually use.
- As more users were added to the repository, recommendation precision increased at the expense of system speed. A greater number of users in the repository meant a greater chance of locating a similar user to the active user. However we don't expect this trend of more users/greater precision to continue indefinitely.

Future Work

- Consider different granularities of similarities between classes. At present we only record method invocations for the entire class. We will extend this to record invocations at the method level.
- Create an intelligent IDE by developing a non-intrusive component recommender as an Eclipse plug-in.
- Provide a feature for explaining recommendations and example use of recommended components by code example.

Conclusions

- Our approach address various shortcomings of previous solutions to the component retrieval problem. Recommendations consider the developer and problem domain without placing any additional requirements on the developer.
- The recommender system extracts knowledge from existing code databases and then exploits this information in future developments.
- As seen, this approach offers real promise for allowing developers discover reusable components with minimal effort.

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