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Chapter 1

The Ferret Package

This chapter describes the GAP package Ferret. Ferret implements highly efficient implementations of a range of search algorithms on permutation groups. If you are interested in if Ferret can be applied to another problem, please contact the authors, who will be happy to look into if your problem can be solved with Ferret.

1.1 Replacing Built-in functionality

Ferret automatically installs methods which replace GAP’s a number of GAP’s built-in functionality:

- *Intersection* for a list of permutation groups.
- *Stabilizer*(G,S,Action) for a permutation group G, and the actions:
  - OnSets
  - OnOnSets
  - OnSetsDisjointSets
  - OnSetsSets
  - OnTuples
  - OnPairs
  - OnDirectedGraph
- *Stabilizer*(G, S) for a permutation group G and a:
  - permutation
  - transformation
  - partial permutation

If you would like to disable this functionality, you can use 1.1.1.

1.1.1 EnableFerretOverloads

```gap
EnableFerretOverloads([active])
```

if active (a bool) is true, then enable Ferret specialisations of Intersection and Stabilizer. Call with active false to disable.
1.1.2  FerretOverloadsEnabled

\[ \text{FerretOverloadsEnabled() (function)} \]

Return if Ferret specialisations of Intersection and Stabilizer are currently enabled.

1.2  Using 'Solve' to solve problems directly

The main method of using Ferret's functionality is the \texttt{Solve (2.1.3)} method. This method intersects a list of permutation groups. The unusual feature is that these permutation groups can be represented in a variety of ways. They can be usual GAP permutation groups given as a list of generators, or they can be the group which is the stabilizer of combinatorial object under some action. Larger problems are then composed from these pieces. For example, the stabilizer of a set $S$ under a group $G$ can be expressed as the intersection of the group which stabilizes the set $S$ and the group $G$. For this problem, there would be no point using \texttt{Solve (2.1.3)}, as GAP’s built in 'Stabilizer' function provides the same functionality. However, with \texttt{Solve (2.1.3)} we can intersect any number of groups at the same time, for example finding the intersection of two groups $G$ and $H$, the stabilizer of a set $S$ and the stabilizer of a set of sets $T$, with the following code:

\begin{verbatim}
Example

\texttt{gap> Solve([ConInGroup(G), ConInGroup(H),
> ConStabilize(S, OnSets), ConStabilize(T, OnSetSets)])}
\end{verbatim}

The currently allowed arguments to \texttt{Solve (2.1.3)} are:

- \texttt{ConInGroup (2.1.2)}, which represents a Permutation Group in GAP
- \texttt{ConStabilize (2.1.1)}, which takes an object and an action.
Chapter 2

The Solve Method

The central functionality of the Ferret package is based around the Solve method. This function performs a backtrack search, using the permutation backtracking algorithm, over a set of groups or cosets. Often users will want to use a higher level function which wraps this functionality, such as Stabilizer or Intersection. The solve function accepts a list of groups, and finds their intersection. For efficiency reasons, these groups can be specified in a variety of different ways. As an example, we will consider how to implement Stabilizer(G, S, OnSets), the stabilizer of a set S in a permutation group G using Solve (this is not necessary, as when Ferret is loaded this method is replaced with a Ferret-based implementation). Another way of viewing Stabilizer(G, S, OnSets) is as the Intersection of G with the Stabilizer of (Sym(n), S, OnSets), where Sym(n) is the symmetric group on n points, and n is at least as large as the largest moved point in G. Solve takes a list of objects which represent groups. Two of these are ConInGroup(G), which represents the group G, and ConStabilize(S, OnSets), which represents the group which stabilizes S. We find the intersection of these two groups by Solve([ConInGroup(G), ConStabilize(S, OnSets)]).

2.1 Methods of representing groups in Ferret

Groups and cosets must be represented in a way which Ferret can understand. The following list gives all the types of groups which Ferret accepts, and how to construct them.

2.1.1 ConStabilize (for an object and an action)

\[
\begin{align*}
\triangleright & \text{ConStabilize}(\text{object}, \text{action}) \\
\triangleright & \text{ConStabilize}(\text{object}, \text{n})
\end{align*}
\]

(function)

This function creates a Constraint which can be given to Solve (2.1.3). It does not perform any useful actions by itself.

In the first form this represents the group which stabilises object under action. The currently allowed actions are OnSets, OnSetsSets, OnSetsDisjointSets, OnSetsTuples, OnTuples, OnPairs and OnDirectedGraph.

In the second form it represents the stabilizer of a partial perm or transformation in the symmetric group on n points.
2.1.2 ConInGroup

ConInGroup(\(G\))  

This function creates a Constraint which can be given to Solve (2.1.3). It does not perform any useful actions by itself. Represents the set of permutations in a permutation group \(G\), as an argument for Solve (2.1.3). These methods are both used with Solve:

2.1.3 Solve

Solve(constraints[, rec])  

Finds the intersection of the list Constraints. Each member of constraints should be a group or coset generated by one of ConInGroup (2.1.2) or ConStabilize (2.1.1). The optional second argument allows configuration options to be passed in. These follow options are supported:

rbaseCellHeuristic (default "smallest")  
The cell to be branched on. This is the option which will most effect the time taken to search. the default is usually best. Other options are: "First" (first cell), "Largest" (largest cell), "smallest2" (the 2nd smallest cell), "random" (a random cell) and "randomsmallest" (one of the smallest cells, choosen randomly)

rbaseValueHeuristic (default "smallest")  
Choose which cell to branch on within a cell. While this will generally make a big difference to search, it is hard to predict the best value, and small changes to the problem will change the best heuristic. Options are the same as rbaseCellHeuristic.

searchValueHeuristic (default RBase)  
The order to branch during search. In general the best order is very hard to predict. Options are "RBase", "InvRBase", "Random", "Sorted" or "Nosort" (which uses the order the values naturally end up in by the algorithm).

searchFirstBranchValueHeuristic (default RBase)  
Choose the search order used just on the left-most branches of search. Allows the same options as searchValueHeuristic

stats (default false)  
Change the return value to provide a range of information about how search performed (implies recreturn). This information will change between releases.

nodeLimit (default false)  
Either FALSE, or an integer which places a limit on the amount of search which should be performed. WARNING: When this option is set to an integer, Ferret will return the current best answer when the limit is reached, which may be a subgroup of the actual result. To know if this limit was reached, set stats to TRUE, and check the nodes.

recreturn (default false)  
Return a record containing private information, rather than the group.
only_find_generators (default true)
By default only find the generators of the group. If false, then find all members of the group.
This option is only useful for testing. If ‘true’, then sets ‘recreturn’ to true.
Chapter 3

Installing and Loading the Ferret Package

3.1 Unpacking the Ferret Package

If the Ferret package was obtained as a part of the GAP distribution from the “Download” section of the GAP website, you may proceed to Section 3.2. Alternatively, the Ferret package may be installed using a separate archive, for example, for an update or an installation in a non-default location (see Reference: GAP Root Directories).

Below we describe the installation procedure for the .tar.gz archive format. Installation using other archive formats is performed in a similar way.

It may be unpacked in one of the following locations:

- in the pkg directory of your GAP 4 installation;
- or in a directory named .gap/pkg in your home directory (to be added to the GAP root directory unless GAP is started with -r option);
- or in a directory named pkg in another directory of your choice (e.g. in the directory mygap in your home directory).

In the latter case one must start GAP with the -l option, e.g. if your private pkg directory is a subdirectory of mygap in your home directory you might type:

gap -l ";myhomedir/mygap"

where myhomedir is the path to your home directory, which (since GAP 4.3) may be replaced by a tilde (the empty path before the semicolon is filled in by the default path of the GAP 4 home directory).

3.2 Compiling Binaries of the Ferret Package

After unpacking the archive, go to the newly created ferret directory and call ./configure to use the default ../.. path to the GAP home directory or ./configure path where path is the path to the GAP home directory, if the package is being installed in a non-default location. So for example if you install the package in the ~/.gap/pkg directory and the GAP home directory is ~/.gap4r5 then you have to call
This will fetch the architecture type for which GAP has been compiled last and create a Makefile. Now simply call

```make```

... to compile the binary and to install it in the appropriate place.

### 3.3 Loading the Ferret Package

To use the Ferret Package you have to request it explicitly. This is done by calling `LoadPackage` (Reference: `LoadPackage`):

```gap```

```true```

If you want to load the Ferret package by default, you can put the `LoadPackage` command into your `gaprc` file (see Section (Reference: The gap.ini and gaprc files)).
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