

ToolsForHomalg

Tools for the homalg project

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(this manual is still under construction)

This manual is best viewed as an HTML document. The latest version is available ONLINE at:

http://wwwb.math.rwth-aachen.de/~gutsche/gap_packages/ToolsForHomalg/chap0.html

An OFFLINE version should be included in the documentation subfolder of the package. This package is part of the homalg-project:

<http://homalg.math.rwth-aachen.de/index.php/core-packages/toolsforhomalg>

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Chapter 1

Introduction

1.1 What is the role of the **ToolsForHomalg** package in the homalg project?

1.1.1 **ToolsForHomalg** provides ...

The package **ToolsForHomalg** provides for the homalg project [[hpa10](#)]:

Chapter 2

Installation of the ToolsForHomalg Package

To install this package just extract the package's archive file to the GAP pkg directory.

By default the ToolsForHomalg package is not automatically loaded by GAP when it is installed. You must load the package with

```
LoadPackage( "ToolsForHomalg" );
```

before its functions become available.

Please, send me an e-mail if you have any questions, remarks, suggestions, etc. concerning this package. Also, I would be pleased to hear about applications of this package.

Mohamed Barakat

Chapter 3

Caches

3.1 Object constructors

Caches are objects which store for a fixed number of keys a value, so they are a map $\text{Obj}^k \rightarrow \text{Obj}$, while the k is fixed. A cache usually stores the result in a weak pointer list, which means that if the value which the cache should store is not referenced in the system anymore, it will not be remembered by the cache. However, caches can be set to store the value permanently (crisp), or not to store any new value at all (inactive). In that case, already stored values are still in the cache and can be accessed once the cache is set active again.

3.1.1 CachingObject (for)

- ▷ `CachingObject([k,][is_crisp])` (operation)
- ▷ `CachingObject(arg)` (operation)
- ▷ `CachingObject(arg1, arg2)` (operation)

Returns: a cache

If no argument is given, the function returns a weak cache with key length one, if an integer k is given, a weak cache with key length k , and if the bool `is_crisp` is true, a crisp cache with the corresponding length.

3.1.2 CachingObject (for IsObject, IsObject, IsInt)

- ▷ `CachingObject(object, cache_name, length[, is_crisp])` (operation)
- ▷ `CachingObject(arg1, arg2, arg3, arg4)` (operation)

Returns:

These methods are not installed, they serve as an interface for `InstallMethodWithCacheFromObject`.

3.2 Setters, getters

3.2.1 CacheValue (for IsCachingObject, IsObject)

- ▷ `CacheValue(cache, key)` (operation)

Returns: stored value

If there is a value stored in the cache for key, which can be a single key for caches with key length one or a list of keys depending on the key length of the cache, this method returns the value, otherwise SuPeRfail.

3.2.2 SetCacheValue (for IsCachingObject, IsObject, IsObject)

▷ SetCacheValue(*cache*, *key*, *value*) (operation)

Returns:

Sets the value of key of the cache to value.

3.2.3 IsEqualForCache (for IsObject, IsObject)

▷ IsEqualForCache(*obj1*, *obj2*) (operation)

Returns: true or false

This function is used to compare objects for the caches. The standard way is IsIdenticalObj, and lists are compared recursive with this function. It is possible and recommended to overload this function as needed.

3.3 Managing functions

3.3.1 SetCachingObjectCrisp

▷ SetCachingObjectCrisp(*cache*) (function)

▷ SetCachingObjectWeak(*arg*) (function)

▷ DeactivateCachingObject(*arg*) (function)

▷ InstallMethodWithCache(*Like*, *InstallMethod*) (function)

▷ InstallMethodWithCrispCache(*arg*) (function)

▷ InstallMethodWithCacheFromObject(*Like*, *InstallMethod*) (function)

▷ FunctionWithCache(*func*) (function)

▷ ToDoListEntryToMaintainEqualAttributes(*indicator*, *objects*, *attributes*) (operation)

▷ ToDoListEntryToMaintainFollowingAttributes(*indicator*, *objects*, *attributes*) (operation)

▷ ToDoListEntry(*source*, *target_list*) (operation)

▷ ToDoList_this_object (global variable)

▷ ToDoListEntryToMaintainEqualAttributesBlueprint(*filter*, *indicator*, *objects*, *attributes*) (operation)

▷ ToDoListEntryToMaintainFollowingAttributesBlueprint(*arg1*, *arg2*, *arg3*, *arg4*) (operation)

▷ ToDoListEntryBlueprint(*arg1*, *arg2*, *arg3*) (operation)

▷ AddToToDoList(*E*) (operation)

▷ SourcePart(*entry*) (operation)

▷ TargetPart(*entry*) (operation)

▷ ProcessAToDoListEntry(*arg*) (operation)

▷ ToDoListEntry(*arg1*, *arg2*, *arg3*, *arg4*) (operation)

▷ ToDoListEntry(*arg1*, *arg2*) (operation)

▷ SetTargetValueObject(*entry*, *value*) (operation)

▷ SetTargetObject(entry, obj) (operation)
 ▷ ToDoListEntryWithContraposition(sobj, source_prop, sval, tobj, target, tval) (operation)
 ▷ DescriptionOfImplication(arg) (attribute)
 ▷ ToDoListEntryForEqualAttributes(arg1, arg2, arg3, arg4) (operation)
 ▷ ToDoListEntryForEquivalentAttributes(arg1, arg2, arg3, arg4, arg5, arg6) (operation)
 ▷ IsToDoList(arg) (filter)
 ▷ NewToDoList(arg) (operation)
 ▷ Process_A_ToDo_List_Entry(arg) (function)
 ▷ ToDoList(arg) (attribute)
 ▷ ProcessToDoList(A) (attribute)
 ▷ TraceProof(obj, name, val) (operation)
 ▷ ActivateToDoList(arg) (operation)
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 ▷ InstallLogicalImplicationsForHomalgBasicObjects(arg) (function)
 ▷ LeftRightAttributesForHomalg(arg) (function)
 ▷ InstallLeftRightAttributesForHomalg(arg) (function)
 ▷ MatchPropertiesAndAttributes(arg) (function)
 ▷ InstallImmediateMethodToPullPropertyOrAttribute(arg) (function)
 ▷ InstallImmediateMethodToConditionallyPullPropertyOrAttribute(arg) (function)
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▷ TOOLS_FOR_HOMALG_GET_REAL_TIME_OF_FUNCTION_CALL(<i>function</i> , <i>args</i>)	(function)
▷ IsTree(<i>arg</i>)	(filter)
▷ Content(<i>arg</i>)	(attribute)
▷ ListOfSuccessors(<i>arg</i>)	(operation)
▷ Predecessor(<i>arg</i>)	(operation)
▷ ListOfSentinels(<i>arg</i>)	(operation)
▷ RemoveHead(<i>arg</i>)	(operation)
▷ Tree(<i>arg</i>)	(operation)
▷ Tree(<i>obj</i>)	(operation)
▷ Add(<i>tree</i> , <i>new_tree</i>)	(operation)
▷ ContentListFromSentinelToHead(<i>sent</i>)	(operation)
▷ PostOrder(<i>arg</i>)	(operation)

Returns: nothing

Sets the caching to crisp, weak, or deativates the cache completely.

Installs a method like `InstallMethod`, but additionally puts a cache layer around it so that the result is cached. It is possible to give the cache as the option `Cache`, to use the same cache for more than one method or store it somewhere to have access to the cache. Like `InstallMethodWithCache`, but with a crisp cache. This works just like `InstallMethodWithCache`, but it extracts the cache via the `CachingObject` method from one of its arguments. The `CachingObject` must then be implemented for one of the arguments, and the option `ArgumentNumber` can specify which option to be used. As second argument for `CachingObject` a string is used, which can identify the cache. Standard is the name of the operation, for which the method is installed, but it can be specified using the `CacheName` option. Creates a cached function out of a given function *func*. If the option `Cache` is a cache, this cache is used. If the option `Cache` is the string `crisp`, a crisp cache is used. All other values for this option lead to a single weak cache. The first argument is the *indicator*. It is a list of sources like in `ToDoListEntry`. Each entry *SP* has to be a threetuple. First entry of *SP* has to be an object, for which the second entry of *SP*, which has to be the name of an attribute, must become known. Once the attribute is known to the object, it will be compared to the third entry of the list. This can be a value, which is compared directly a function, which is launched and its return value is compared, or a list, consisting of a function and arguments, so the return value of the function with given arguments is compared. If there is no third entry in *SP*, it is only looked up if the value is known. Once all entries in *indicator* are processed like this, and all returned true in the comparison, a list of `ToDoListEntryForEqualAttributes` is installed. They are installed for the two entries of the list *objects* which can either be the objects itself or a list containing a function and arguments, which return value is used. For each entry in *attributes* such an entry is installed. Such an entry can be the name of an attribute, if both objects in *objects* should share the value between attributes with the same name, or a list of two names, if the attributes do not have the same name. This function creates a `ToDoListEntry` which can install several `ToDoListEntries`. The first two arguments, *indicator* and *objects* except that there will be only `ToDoListEntries` installed between the two objects in *objects*. Each entry in *attributes* can either be a string which means that the attribute with the given name will be set from the first to the second object in *objects* once it is known. The third argument *attributes* is a list of attributes that will be propagated by `ToDoListEntries`. Each entry *TP* can either be a list consisting of a `DescriptionOfImplication` string and one of the following or just one of the following lists: It can be a string, which means that the Attribute with the given name will be propagated from the first to the second object. It can be a list, consisting of two entries, where the first entry is a list of sources like in `ToDoListEntry` and the second might be a function which will be launched once the first part is fulfilled. It can also be a threetuple which will serve as second to fourth argument of `ToDoListEntry`. Or it can be a string, which will set the attribute named like this of the first object to the one named in the second object. This function allows to create more than one `ToDoListEntry` with identical list of sources at one time. First argument is a list of sources like in the other `ToDoListEntry` functions. Second argument is a list of threetuples, which serve as second to fourth argument of `ToDoListEntry` or a function, which serves as second argument for `ToDoListEntry` or a tuple with a description string and one of the above. Represents the objects for which the blueprint is created in the arguments. This function installs an immediate method which can install `ToDoListEntryToMaintainEqualAttributes`. First argument must be a filter, and once the filter becomes true the `ToDoListEntryToMaintainEqualAttributes` is installed with the second to fourth argument as first to third. In those attributes, at any point, the variable `ToDoList_this_object` can be used. When the entry is installed this will be replaced with the object to which the filters became known, i.e. the one which triggered the immediate method. The same as `ToDoListEntryToMaintainEqualAttributesBlueprint` for `ToDoListEntryToMaintainFollowingAttributes`. The same as `ToDoListEntryToMaintainEqualAttributesBlueprint` for `ToDoListEntry`. Adds the `ToDo-list` entry *E*

to the ToDo-lists of its source objects and creates a new one, if this is needed. This function might be called with lists of entries. Returns a list of source parts of the ToDo-list entry *entry*. This is a triple of an object, a name of a filter/attribute, and a value to which the attribute has to be set to activate the entry. Returns the target part of the ToDo-list entry *entry*. This is a triple of an object, a name of a filter/attribute, and a value to which the specific filter/attribute should be set. The third entry of the list might also be a function to which return value the attribute is set. Processes a ToDo-list entry, i.e. sets the information given in TargetPart if the definitions in SourcePart are fulfilled. Returns a function if the entry could be processed, false if not, and fail if SourcePart or TargetPart weren't available anymore. The first argument must be a list consisting of two, three or four-tuples where the first entry must be the object to which the attribute given as a string in the second entry must be known to process this entry. The second entry can also be a list of strings, in that case all the attributes given as names must be known. Also, in this case, only two entries in this tuple are allowed. The third part can be a value or a list, consisting of a function followed by arguments which will be computed by the time the attribute given as second entry becomes known to the first entry. If the second part is only a string, and there is a third entry in the tuple the attribute is compared to the third entry. One can set a comparing function as fourth entry, which must take two entries and return false or true. If the value of the attribute matches the (computed) value in the third entry for all members of the list in the first argument the attribute given as third argument, also by name, of the second argument is set to the value of the fourth argument. This can also be a list which has to be computed, or a function, which return value is used in this case. The first argument is a list of three-tuples like above. Once all preconditions become fulfilled the function given as second argument is launched. If the given value of the target part is the return value of a function this command sets the target value of the entry to a function. This is done to keep proof tracking available. If the target object, i.e. the first entry of the target part, was given as a function, this method can set this entry to the return value computed in ProcessToDoListEntry. This happens automatically, do not worry about it. Creates a ToDoListEntry which also installs a contraposition. The arguments *source_prop* and *target* need to be strings which name a property, and *sva1* and *tva1* need to be boolean values, i.e. true or false. Has to be set to a string, which describes the reason for the conclusion. If the ToDo-list entry is displayed, the given string will be displayed with a because before it. Creates a ToDoListEntry for two equal attributes, which means that both values of the two attributes will be propagated in both directions. Creates a ToDoListEntry for two equivalent attributes, which means that both values of the two attributes will be propagated in both directions. Please note that this one does NOT implement contrapositions. This is the category of ToDo-lists. Every ToDo-list is an object of this category, which basically contains the ToDo-lists. Creates a new empty ToDo-list. Gets a ToDo-list entry, which is a pair of a list of strings and a weak pointer object, and processes it. If the action was done, it returns true, if not, it returns false, and it returns fail if the action is not possible anymore due to deleted objects. Returns the ToDo-list of an object, or creates a new one. This is the magic! This attribute is never set. Creating an ToDo-list entry installs an ImmediateMethod for this attribute for the specific category of the object to which ToDo-list is added, and the filter the entry contains. It is then triggered if the filters become applicable, so the ToDo-list is processed. If the object *obj* has the attribute *name*, and its value is *val*, and the knowledge has been obtained through ToDoList-entries, this method traces the way the property was set, and returns a tree which describes the full way of how the attribute became known. This operation activates ToDoLists for the argument. This operation activates ToDoLists for all objects. This operation deactivates ToDoLists for the argument. This operation deactivates ToDoLists for all objects. Note that it is not possible to activate ToDoList for a single object while they are not activated. ToDoListEntries will yet be stored for all objects that can have ToDoLists. All objects created while ToDoLists are deactivated have by default no ToDoList. Stores the result

of Where(100) in an entry if the entry is triggered. This is not activated by default, since it might slow down the system. Deactivates the storage of the result of Where(100) if an entry is triggered. This is the default. A central place for configurations. ChapterInfo Basics, Variables This is the super super GAP-category which will include the GAP-categories IsStructureObjectOrObject and IsHomalgObjectOrMorphism This is the super GAP-category which will include the GAP-categories IsHomalgRing, IsHomalgModule, IsHomalgRingOrModule and IsHomalgComplex This is the super GAP-category which will include the GAP-categories IsHomalgRing we need this GAP-category to define things like $\text{Hom}(M,R)$ as easy as $\text{Hom}(M,N)$ without distinguishing between structure objects (e.g. rings) and objects (e.g. modules) This is the super GAP-category which will include the GAP-categories IsHomalgRingMap, etc. this is the super GAP-category which will include the GAP-categories IsHomalgRing, IsHomalgModule: The category for weak pointer objects The category for pointer objects The constructor for lists of weak pointers. A tool to compute the runtime of several methods. A tool to install equivalence between filters. Installs a logical implication for one type with all it's contrapositions.

A method to match the properties and attributes of two objects. Installs methods to pull new known properties and attributes from one object to another Installs methods to pull new known properties and attributes under certain conditions from one object to another. Installs an immediate method which can pull a property from one object to another with different names. Installs an immediate method to pull several properties or attributes from one object to another. Installs an immediate method to pull a property if it is true. Installs an immediate method which conditionally pulls a property if it is true. Installs an immediate method which pulls a property with a different name if it is true. Installs an immediate method which pulls several properties if they are true Installs an immediate method to pull a property if it is false. Installs an immediate method which conditionally pulls a property if it is false. Installs an immediate method which pulls a property with a different name if it is false. Installs an immediate method which pulls several properties if they are false. Installs an immediate method to push a property from one object to another. Installs an immediate method to conditionally push a property from one object to another. Installs an immediate method which can push a property from one object to another with different names. Installs an immediate method to push several properties or attributes from one object to another. Installs an immediate method to push a property if it is true. Installs an immediate method which pushes a property with a different name if it is true. Installs an immediate method which pushes several properties if they are true Installs an immediate method to push a property if it is false. Installs an immediate method which pushes a property with a different name if it is false. Installs an immediate method which push several properties if they are false. Installs an attribute with a custom getter function. Appends an entry to a homalg table. Creates a list of integers out of the names of components. Increases an existing counter in an object. Increases an existiiing counter on an object with timing. Increases a counter in an object and creates one if it not exists Converts the current memory state to a string Returns the p -exponent of the integer n , where p is a rational prime. Apply ViewObj to the list L . Runs the examples for homalg if the package is loadable. Runs the named example for homalg Updates the weak pointers in a container and deletes the empty ones Adds a weak pointer of an objects to a weak pointer list. Adds a weak pointer which depends on two objects to a list of weak pointers Creates a weak pointer depending on two objects and adds it to the container. Creates a container for pointers. Updates the container of pointers, removes old. Adds a pointer to an object to a container for pointers. Adds a pointer to two objects to a container for pointers Returns an object

which a pointer refers to. Returns real time seconds of the call function(args) as first entry of list, result of call as second. The category of trees. A tree may have a content, a list of successors, a predecessor and it knows if it is a leave of a tree or not. The content of the tree. May be any object. Returns the list of successors of a tree. Returns the predecessor of a tree, or fail if there is none. Returns a list of leaves of the tree. Returns the first successor of the tree, and adds all other successors of the tree to the tree that is returned. If the tree is a leave, it returns an empty tree. If the tree is empty, it returns the tree itself. Returns an empty tree. Returns a tree with argument *obj*. Adds the [list of] tree[s] *new_tree* as successor to the tree *tree*. Returns a list of the contents of the trees from the leave *sent* up to the content of the head of the tree. Returns the contents of the nodes of the tree in post-order.

Chapter 4

ToDo-list

4.1 Proof tracking

This is a way to track proofs from ToDoLists. Not only for debugging, but also for knowing how things work together.

Chapter 5

Trees

The trees are used in ToDoLists. They are a technical feature, and fairly general, so they also can be used somewhere else.

References

- [hpa10] The homalg project authors. *The homalg project*, 2003-2010. <http://homalg.math.rwth-aachen.de/>. 4

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