Automated Software Transplantation

Earl T. Barr  Mark Harman  Yue Jia  Alexandru Marginean  Justyna Petke

CREST, University College London
Why Autotransplantation?
Why Autotransplantation?
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Why not handle H.264?
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Start from scratch

VLC
Why Autotransplantation?

Why not handle H.264?

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Check open source repositories

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Why Automated Software Transplantation?

- Why not handle H.264?
- Check open source repositories
- Start from scratch
- ~100 players
(G) The result solves a problem of indisputable difficulty in its field.
Human Competition

**x264**

```c
char *vF;
vF = getFile();
initCodec(vF);
Stream *ds = decodeFile(vF);
encodeStream(ds, out);
```

**VLC**

```c
char *iF = getInputFile();
char *oF = getOutputFile();
```
Human Competition

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Human Competition

**x264**

**VLC**

```c
char * iF = getInputFile();
char * oF = getOutputFile();

if = getFile();
initCodec(iF);

Stream *ds = decodeFile(iF);
encodeStream(ds, oF);
```
Human Competition

```c
char * iF = getInputFile();
char * oF = getOutputFile();

if = getFile();
initCodec(if);

Stream *ds = decodeFile(if);
encodeStream(ds, of);
```
Our Approach

μSCALPEL
Our Approach

μSCALPEL
Our Approach

μSCALPEL
Result: x264 & VLC
Result: x264 & VLC

Award winning tool for H.264 encoding [2,3,4]

Donor

Host
Result: x264 & VLC

Award winning tool for H.264 encoding [2,3,4]

“Most popular desktop video player” [1]
Result: x264 & VLC

Award winning tool for H.264 encoding [2,3,4]

“Most popular desktop video player” [1]

Organ: H264

Donor

Host
Result: x264 & VLC

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Award winning tool for H.264 encoding [2,3,4]

“Most popular desktop video player” [1]
**Result: x264 & VLC**

### Automatic Transplantation of H264 Encoder

<table>
<thead>
<tr>
<th></th>
<th>Time (hours)</th>
<th>Regression Tests</th>
<th>Manual Tests</th>
<th>Acceptance Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu$SCALPEL</td>
<td>26</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

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**Donor** → **Organ: H264** → **Host** → **Postoperative**
Autotransplantation vs Human Transplantation
Autotransplantation vs Human Transplantation
Autotransplantation vs Human Transplantation
Autotransplantation vs Human Transplantation

- 26 hours of cheap machine time

- Upgrade of x264 within VLC: average of 20 days of elapsed time
μSCALPEL

26 hours of cheap machine time

Upgrade of x264 within 1.5 average of 20 days of elapsed time

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(H) The result holds its own or wins a regulated competition involving human contestants (in the form of either live human players or human-written computer programs).

(C) The result is equal to or better than a result that was placed into a database or archive of results maintained by an internationally recognised panel of scientific experts.
The printing press predated font design competitions.
Regulated Competition

The printing press predated font design competitions.

μSCALPEL predates transplantation competitions.
The printing press predated font design competitions.

μSCALPEL predates transplantation competitions.

We hope so 😊
Regulated Competition
Regulated Competition

MSU Sixth MPEG-4 AVC/H.264 Video Codecs Comparison [4]

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Regulated Competition

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Regulated Competition

x264 won with ~24% better encoding than second place

MSU Sixth MPEG-4 AVC/H.264 Video Codecs Comparison [4]
Regulated Competition

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Regulated Competition

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Regulated Competition

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2.4% faster
Regulated Competition

MSU Sixth MPEG-4 AVC/H.264 Video Codecs Comparison [4]

2.4% faster

We automatically transplanted new functionality!
Regulated Competition

MSU Sixth MPEG-4 AVC/H.264 Video Codecs Comparison [4]

2.4% faster

WINNER

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(E) The result is equal to or better than the most recent human-created solution to a long-standing problem for which there has been a succession of increasingly better human-created solutions.

(F) The result is equal to or better than a result that was considered an achievement in its field at the time it was first discovered.
Long Standing Problem
Long Standing Problem
Long Standing Problem

ITU-T

ISO

Long Standing Problem

ITU-T
- H.261

ISO
- MPEG1

Long Standing Problem

ITU-T

H.261

ISO

MPEG1

MPEG2

Long Standing Problem

ITU-T
- H.261
- H.263
- H.263++

ISO
- MPEG1
- MPEG2
- MPEG4


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Long Standing Problem

ITU-T
- H.261
- H.263
- H.263+
- H.263++
- H.264

ISO
- MPEG1
- MPEG2
- MPEG4

Long Standing Problem

ITU-T

H.261
H.263
H.263+
H.263++
H.264
H.265

ISO

MPEG1
MPEG2
MPEG4

Long Standing Problem

ITU-T

H.261
H.263
H.263+
H.263++
H.264
H.265

ISO

MPEG1
MPEG2
MPEG4

Are We Really Human-Competitive? “Am I Obsolete?”
Are We Really Human-Competitive? “Am I Obsolete?”

5th August 2015 10:46

**DimPrawn**
Richer than sasguru

I am obsolete

Code & #39;transplant& #39; could revolutionise programming (Wired UK)

Code has been automatically "transplanted" from one piece of software to another for the first time, with researchers claiming the breakthrough could radically change how computer programs are created.

The process, demonstrated by researchers at University College London, has been likened to organ transplantation in humans. Known as MuScalpel, it works by isolating the code of a useful feature in a ‘donor’ program and transplanting this "organ" to the right "vein" in software lacking the feature.

Bugar, no one is going to hire me now. 😞

5th August 2015 10:53

**BrilloPad**
**TripleIronDad**
BrilloPad is a fount of knowledge

Couple that to a 3D printer and the ruling class will not need the plebs soon.
Maybe we will all be sent to the gas chambers.
Are We Really Human-Competitive? “Am I Obsolete?”

**UK Contractor Forum**

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**DimPrawn**
Richer than sasguru
DimPrawn - scorchio!

- I am obsolete
  Code &nbsp;#39;&nbsp;transplant&nbsp;&nbsp;#39; could revolutionise programming (Wired UK)
  
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  The process, demonstrated by researchers at University College London, has been likened to organ transplantation in humans. Known as MuScalpel, it works by isolating the code of a useful feature in a 'donor' program and transplanting this "organ" to the right "vein" in software lacking the feature.
  
  Bugger, no one is going to hire me now. 😞

---

**BrilloPad**

- BrilloPad
  TripleIronDad
  BrilloPad is a fount of knowledge

---

**Anirban**
@anirbanbasu

MuScalpel - code transplantation is here. So in the next 10 years there would be no jobs for computer programmers...
Why is Autotransplantation the Best?
Why is Autotransplantation the Best?

Code reuse is a seminal problem in computer science.
Automatic moving code is a difficult problem.
First transplant of useful, non-trivial functionality between two unrelated systems.
First application of GP to transplant functionality between two unrelated systems.
Why is Autotransplantation the Best?

x264
63K LOCs

Organ: H264
23k LOCs

VLC
422K LOCs
Why is Autotransplantation the Best?

Popular, substantial, real world systems.
Media encoding is an increasingly important problem.
Media encoders compared in various competitions [2,3,4].
As a side effect of GP we are 2.4% faster than the best H.264 encoder.
Why is Autotransplantation the Best?
Why is Autotransplantation the Best?

Coding 'transplant' could revolutionise programming [wired.uk/HZhIIID]

WIRED article, with more than 2000 shares
Why is Autotransplantation the Best?

article, with more than 2000 shares
Why is Autotransplantation the Best?

“the BBC’s biggest global brand with sales of the TV show, DVDs, books, live shows and other merchandise worth more than £50m a year” [5]
Why is Autotransplantation the Best?

article, with more than 2000 shares
Why is Autotransplantation the Best?

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Why is Autotransplantation the Best?

article, with more than 2000 shares

More shares for Autotransplantation!
Why is Autotransplantation the Best?
Why is Autotransplantation the Best?

ACM Distinguished Paper Award at ISSTA ‘15
Why is Autotransplantation the Best?

ACM Distinguished Paper Award at ISSTA ‘15

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BBC WORLD SERVICE

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MOTHERBOARD

Wi-Fi Aware Connects Smartphones

Click talks to Kelly Danka-Peter of the Wi-Fi Alliance about the latest developments of Wi-Fi Aware, which will make
Wi-Fi Aware projects easier to find and connect with the latest networks.

Available now • 28 minutes

Muckitapel is an Algorithmic Code Transplantation Tool

A new system offers an automated way of reusing ("transplanting") existing code into new projects.
Contributions
Contributions

We automatically transplanted H.264 encoder from x264 into VLC.
Contributions

We automatically transplanted H.264 encoder from x264 into VLC.

As a side-effect of GP, our transplant is faster than the winner of many encoder competitions.
Why is Autotransplantation the Best?

We automatically transplanted H.264 encoder from x264 into VLC.

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Autotransplantation vs Human Transplantation

Autotransplantation

μSCALPEL

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- 100 players
- Check open source repositories

Why not handle H.264?

More shares for Autotransplantation!

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References


