Périphériques d'interaction, pointage, latence et fonctions de transfert

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Master Informatique - RVA - IHMA

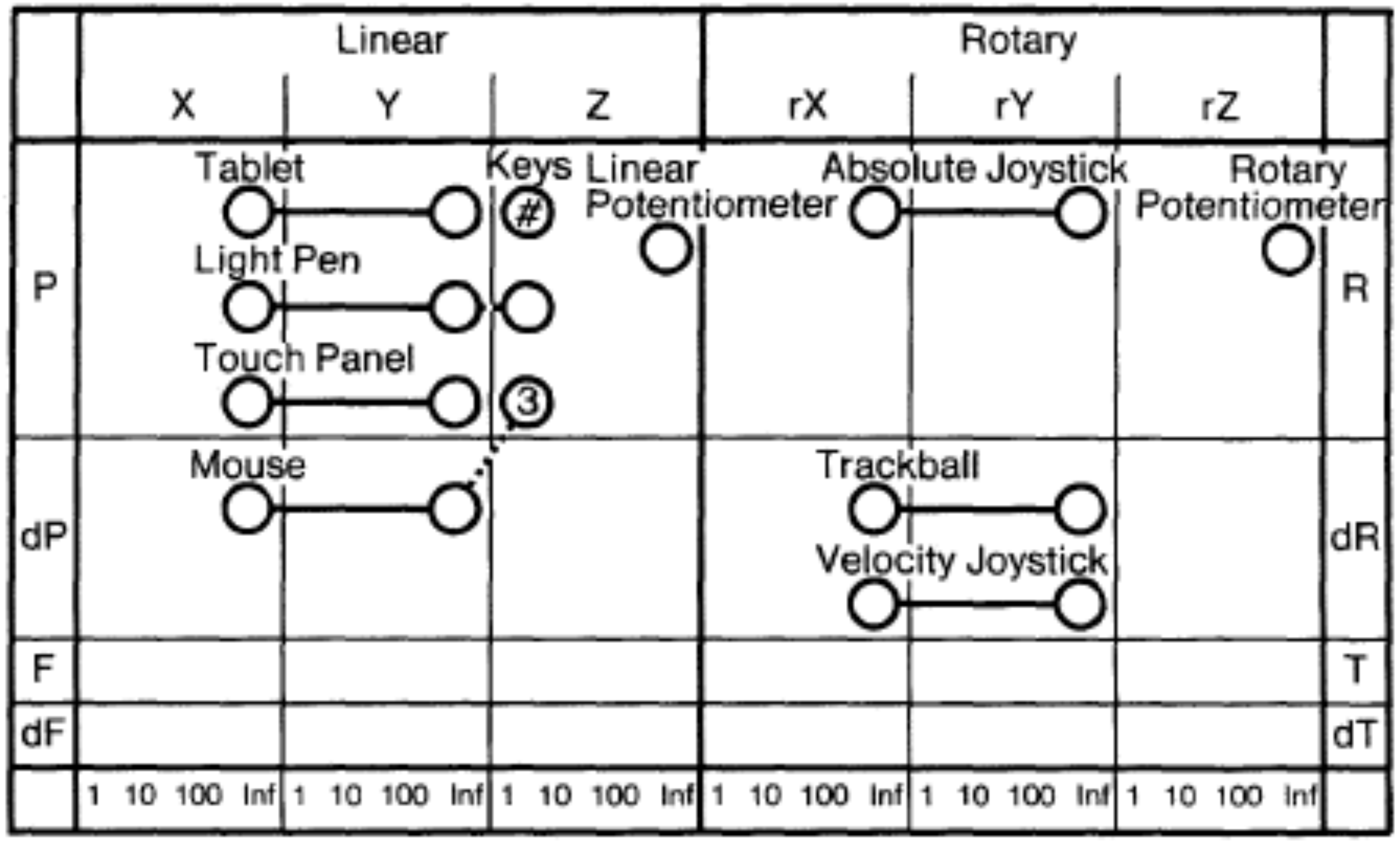
Tâche élémentaires d’interaction

- **Select** : pointer un objet (menu, bouton, etc.)
- **Position** : placer un objet sur 1, 2, 3 ou plus de dimensions
- **Orient** : orienter un objet sur 1, 2, 3 ou plus de dimensions
- **Path** : dessiner une ligne, courbe, etc.
- **Text** : saisir du texte
- **Quantify** : saisir une valeur scalaire

James D. Foley , Victor L. Wallace , Peggy Chan, 1984
The human factors of computer graphics interaction techniques
IEEE Computer Graphics and Applications, 4(11), 13-48

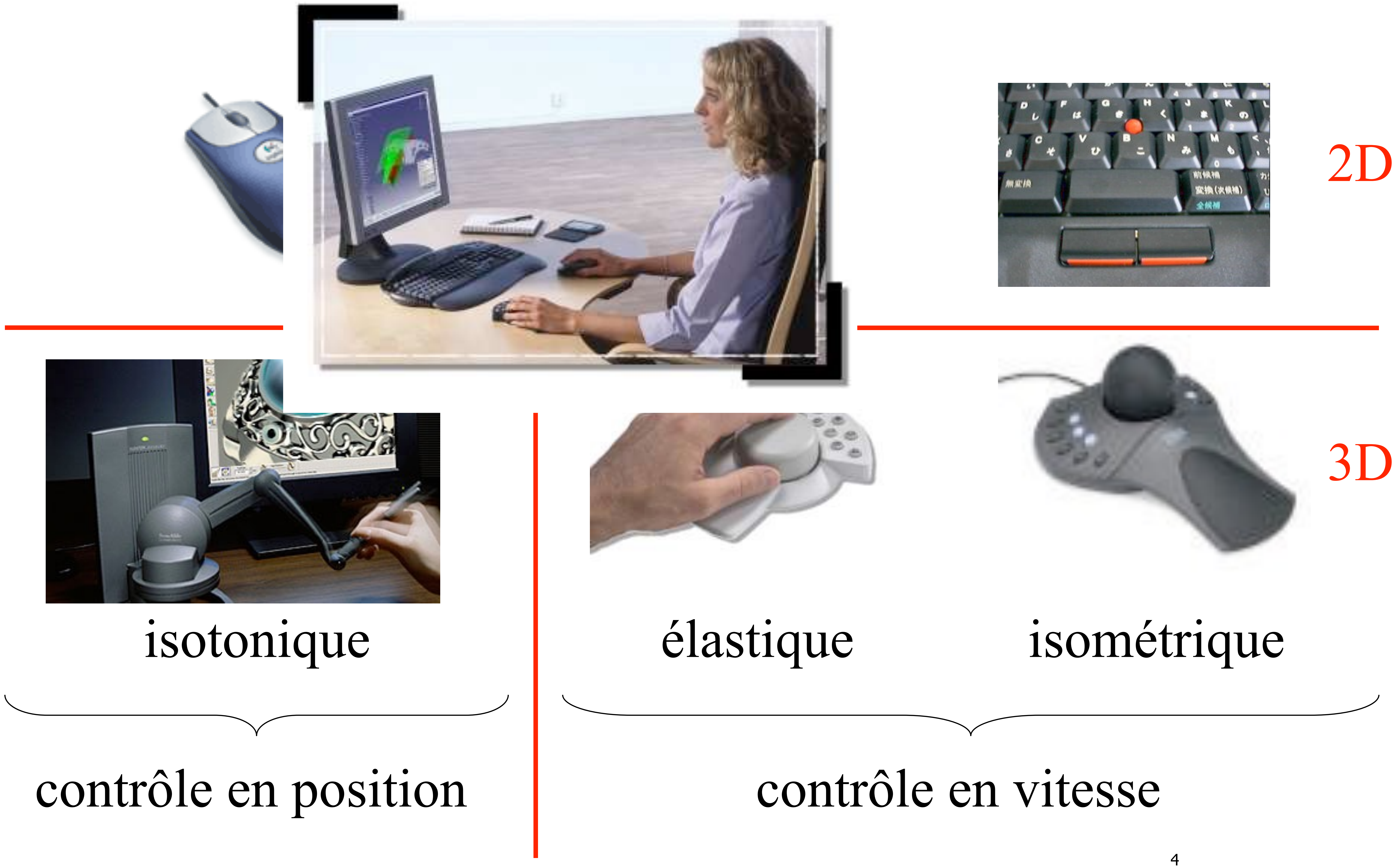
Taxonomie des périphériques d'interaction

- Nature des degrés de liberté : discrets ou continus
- Agencement des degrés de liberté : intégrés ou séparés
- Grandeur physique mesurée

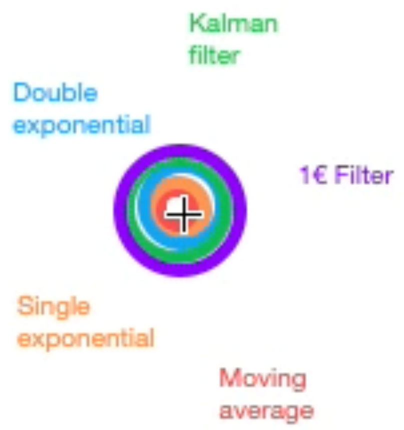


Jock D. Mackinley, Stuart K. Card, George G. Robertson , 1990
A Semantic Analysis of the Design Space of Input Devices
Journal of Human-Computer Interaction, 5 (2), 145-190.

Degré de résistance des ddl



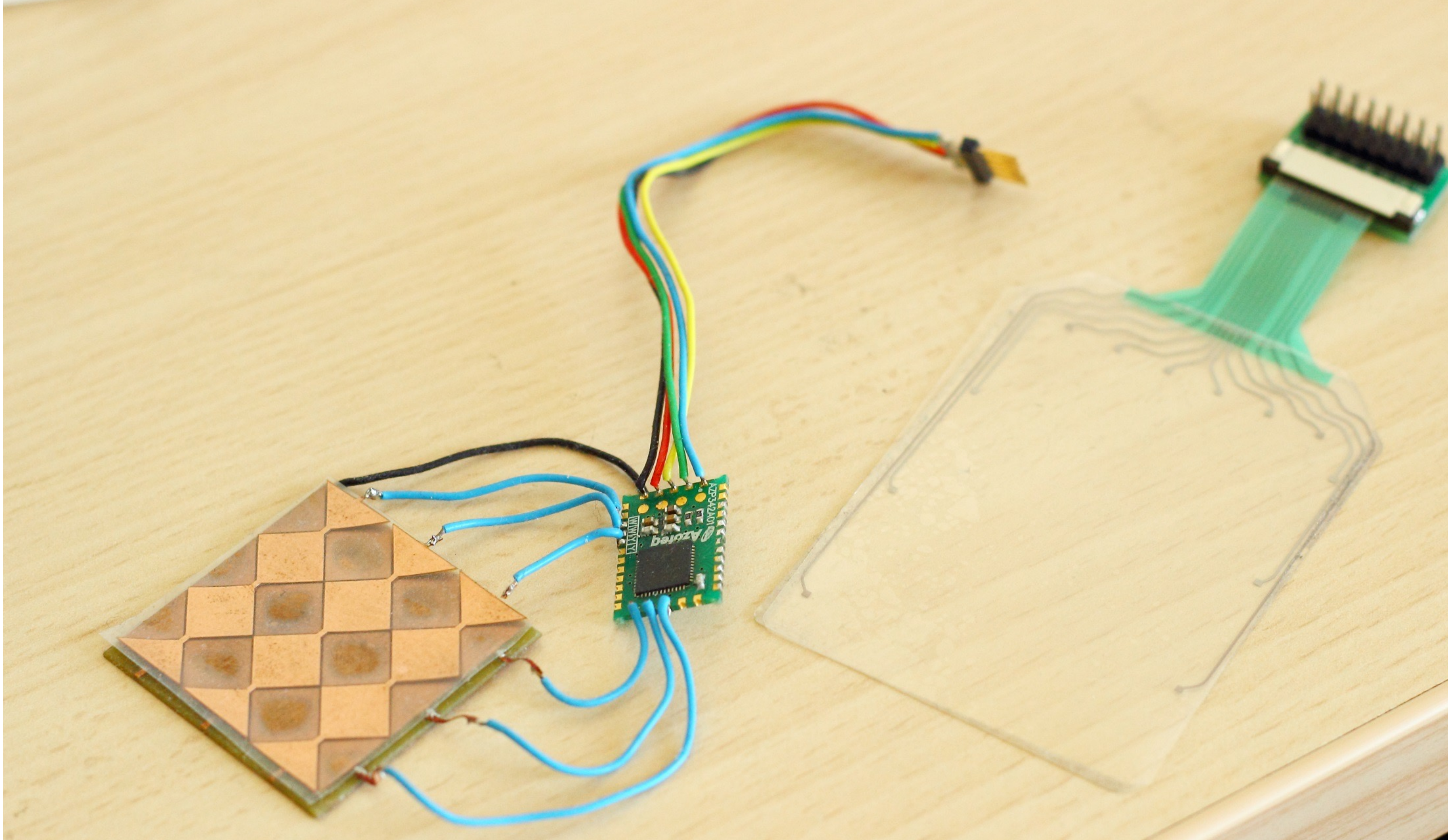
https://gery.casiez.net/1euro/



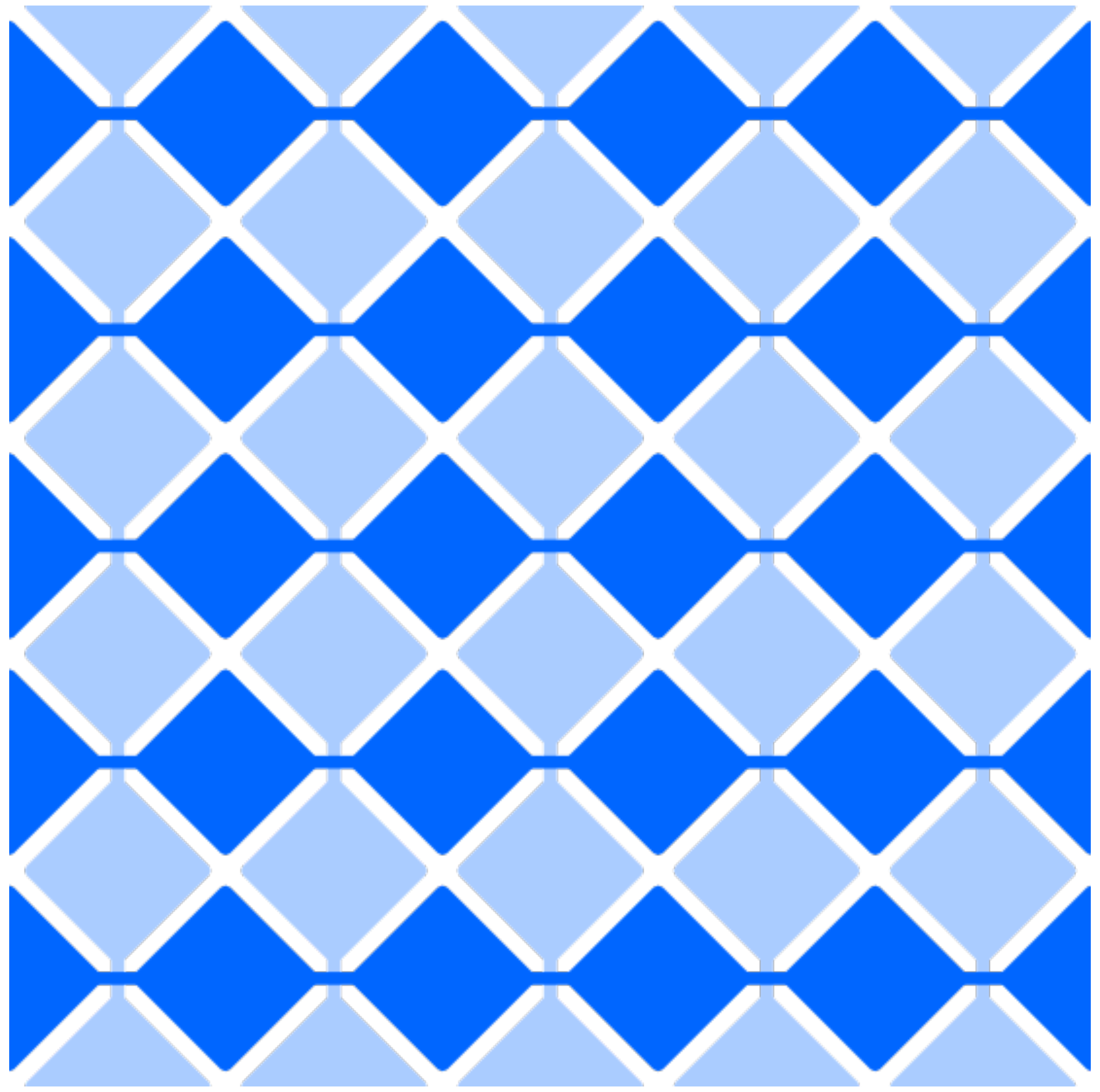
[Casiez et al. 2012]

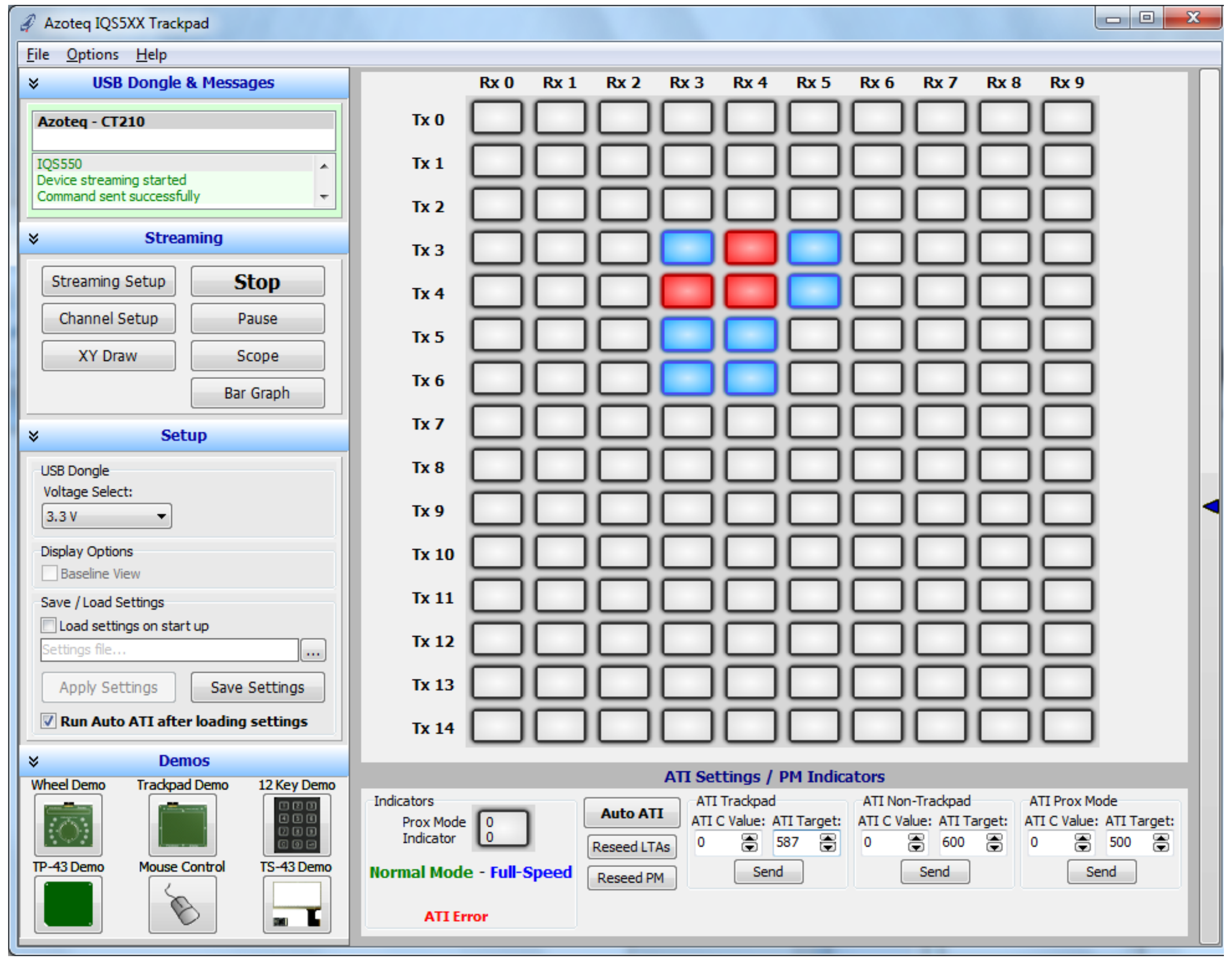
Interaction directe

[Vogel & Baudisch 2007]

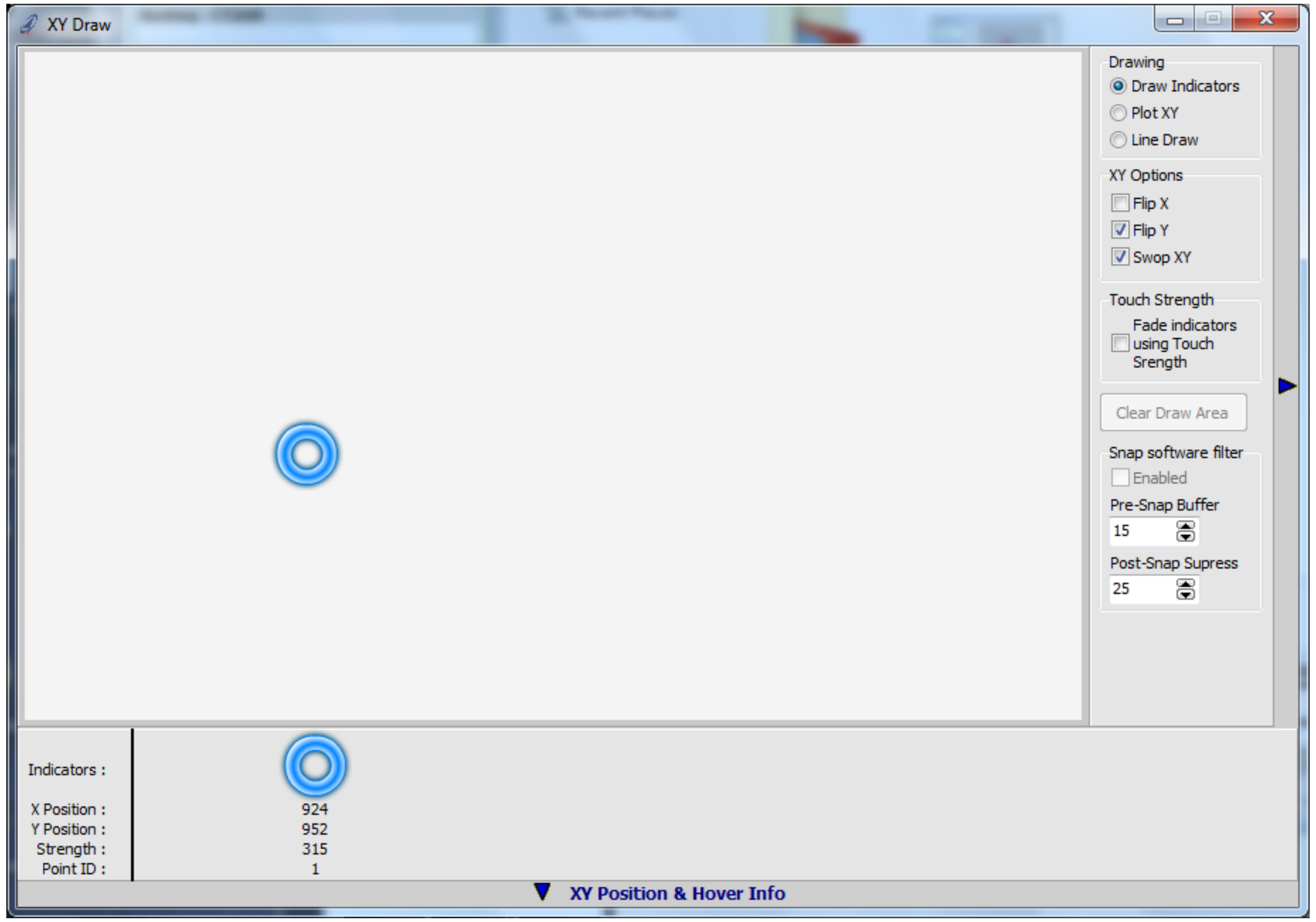

AZP342A01
Azoteq

Multitouch capacitif





- Mesure de capacité
- Lignes × Colonnes
- 2 couches
- Mesure à chaque intersection
- Calcul des centroïdes




BIBLIOTHEQUE
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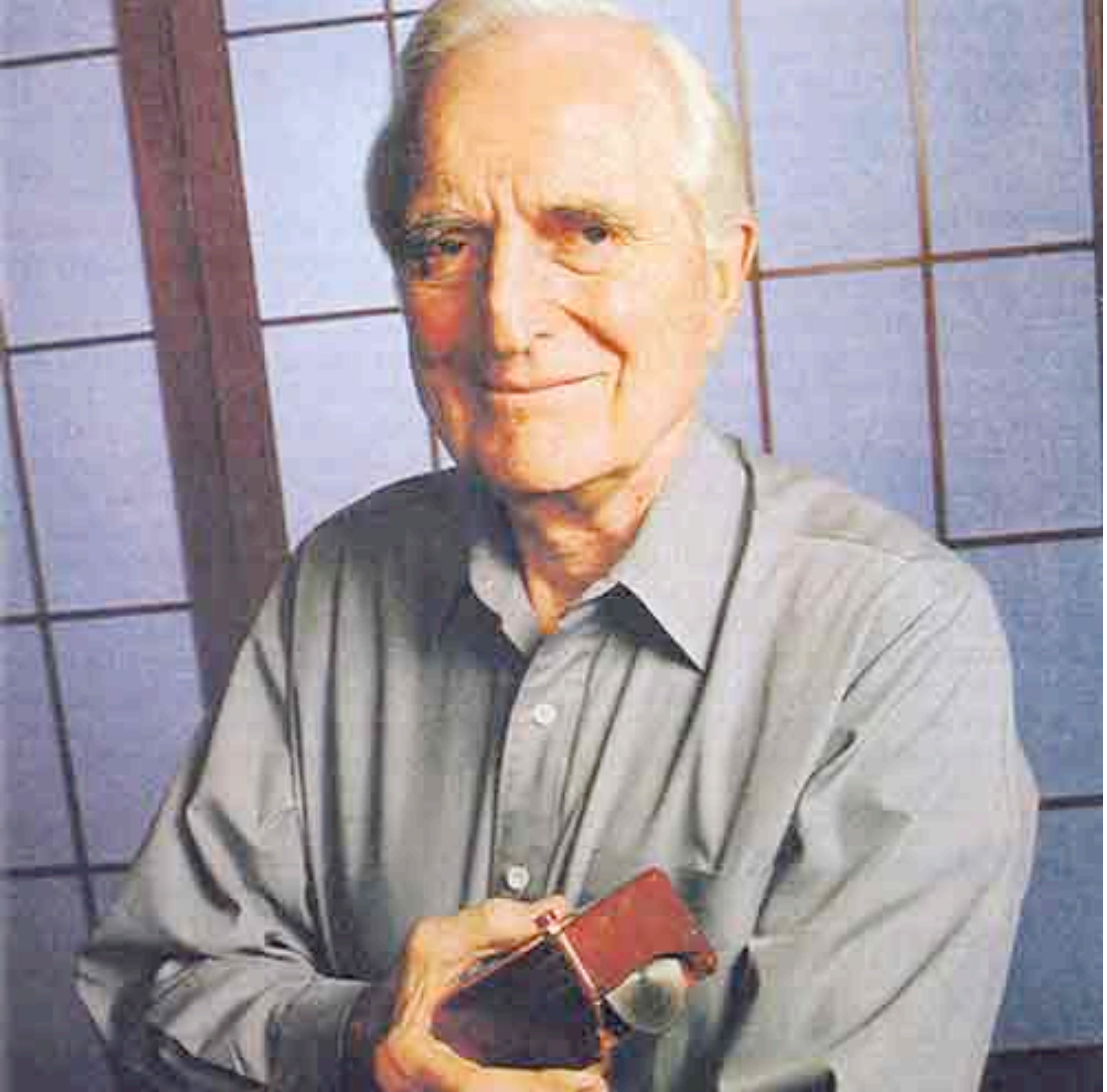
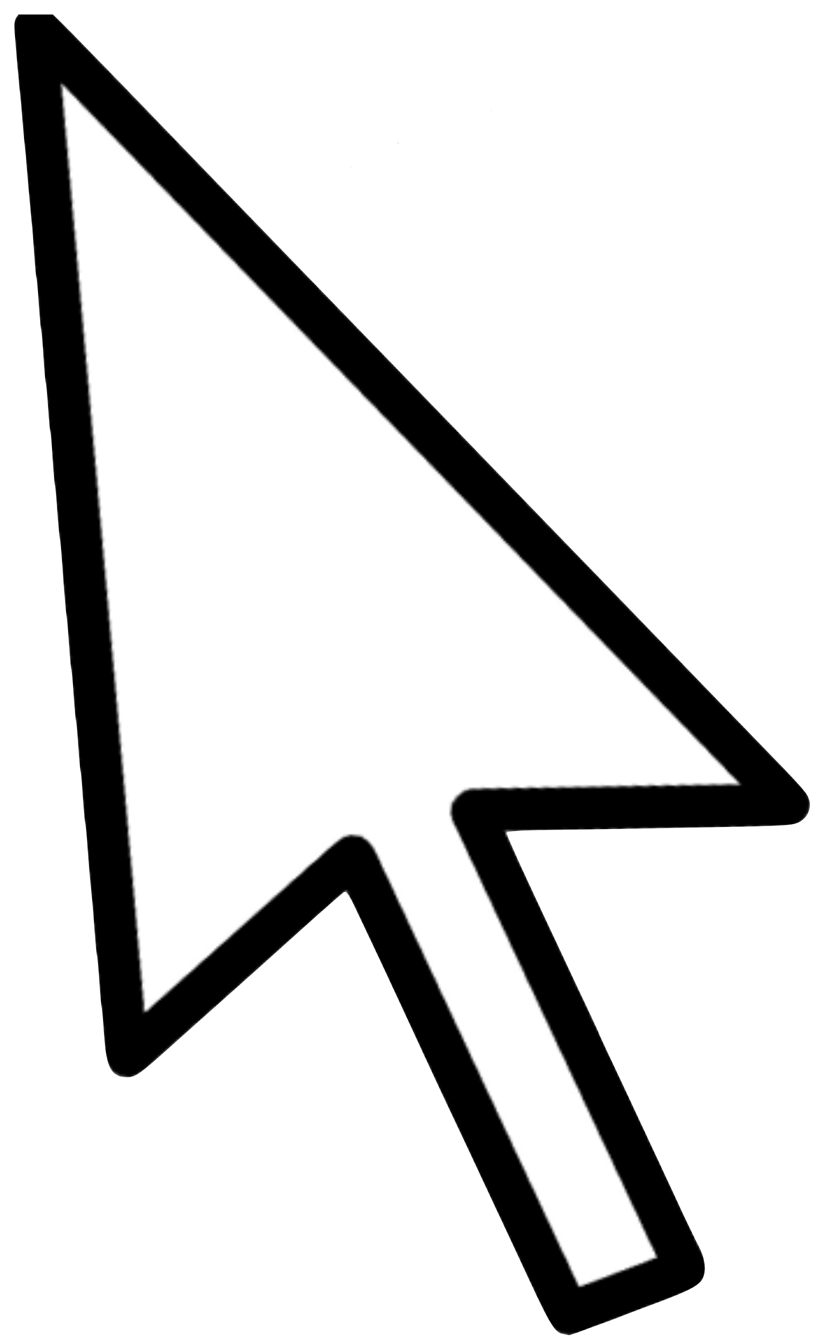
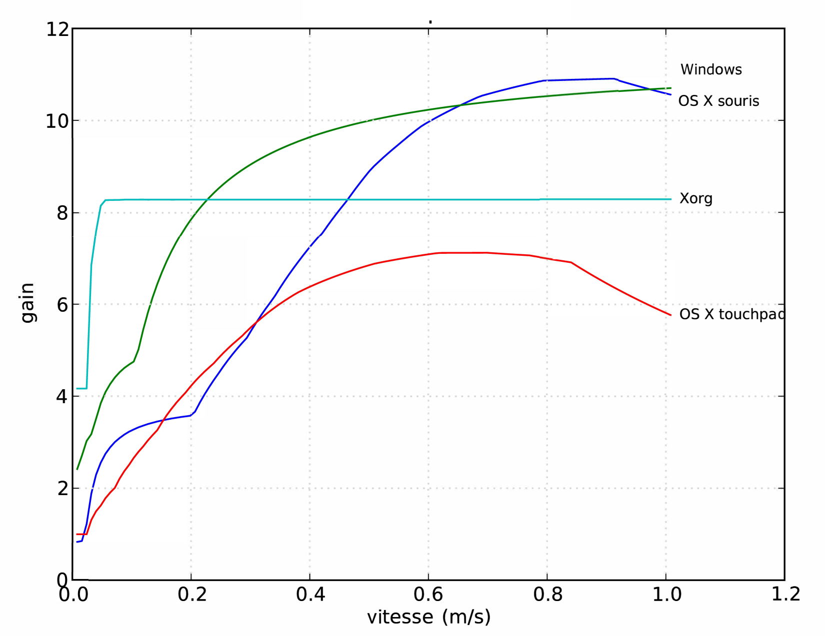
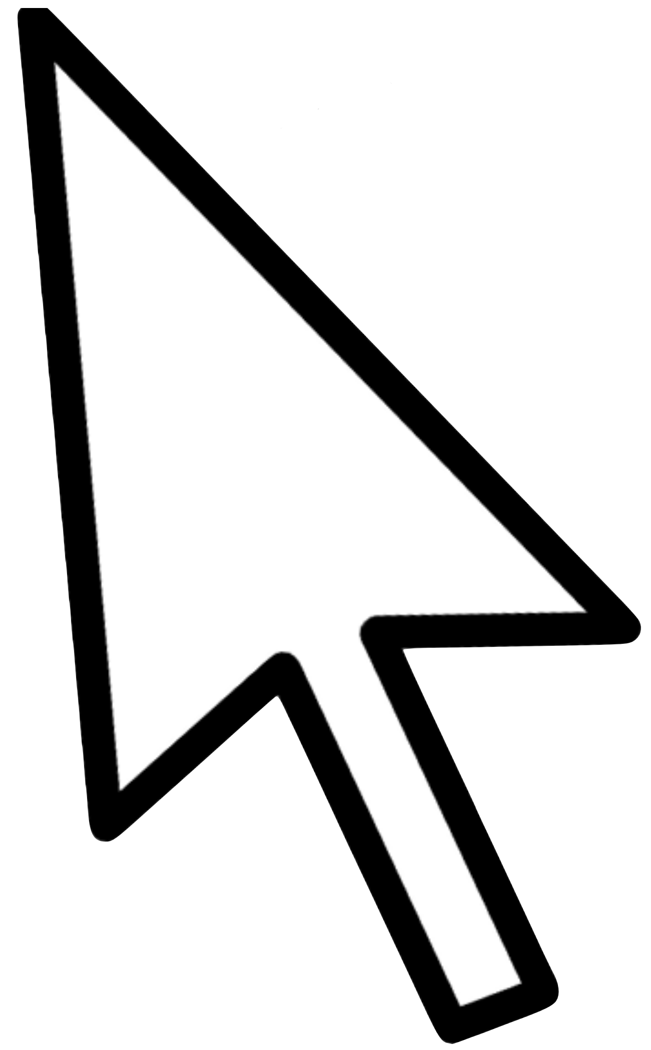


Interaction indirecte

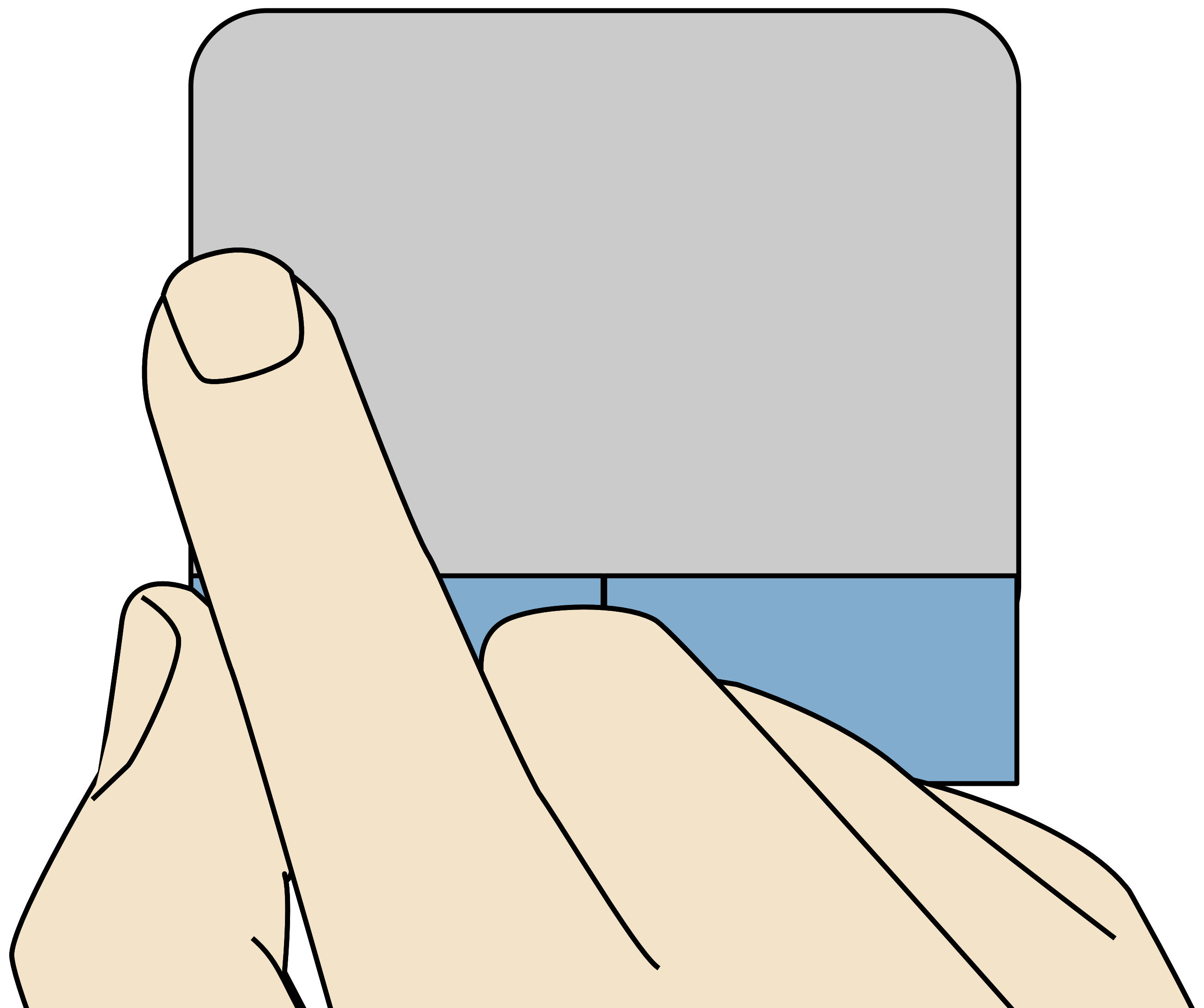




Fonction de transfert



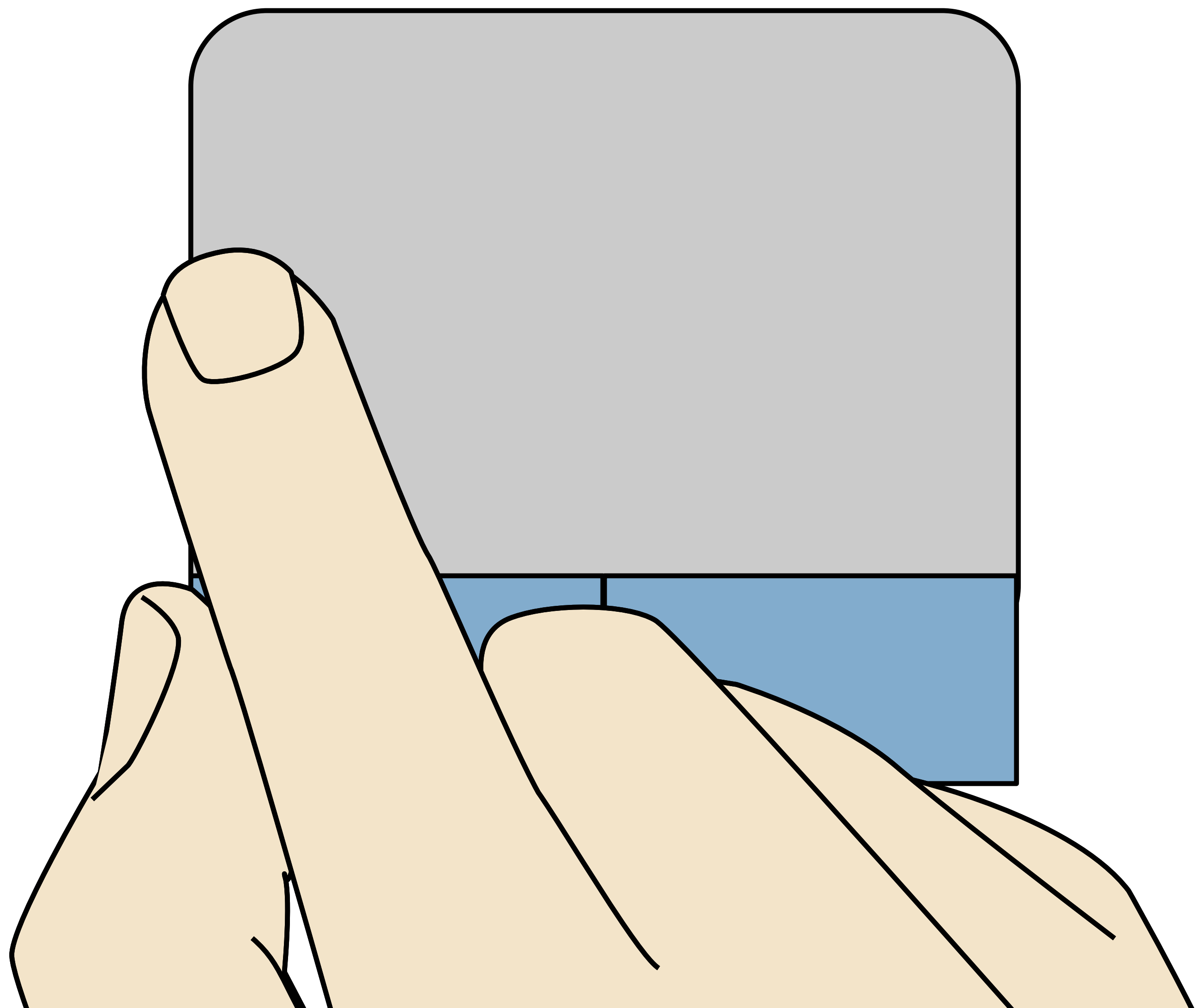
Relation linéaire

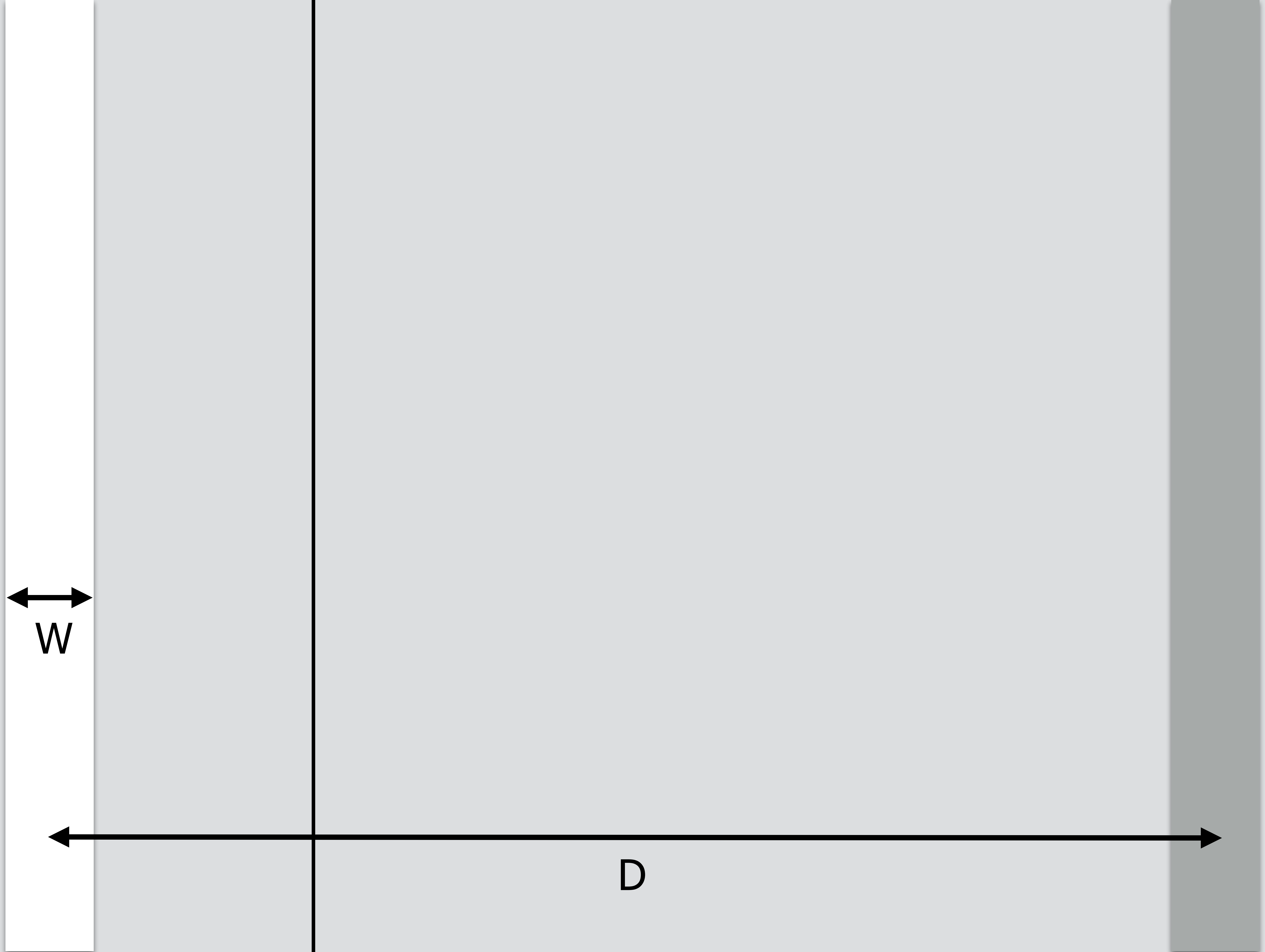


Gain = 1

Relation linéaire

Gain = 4



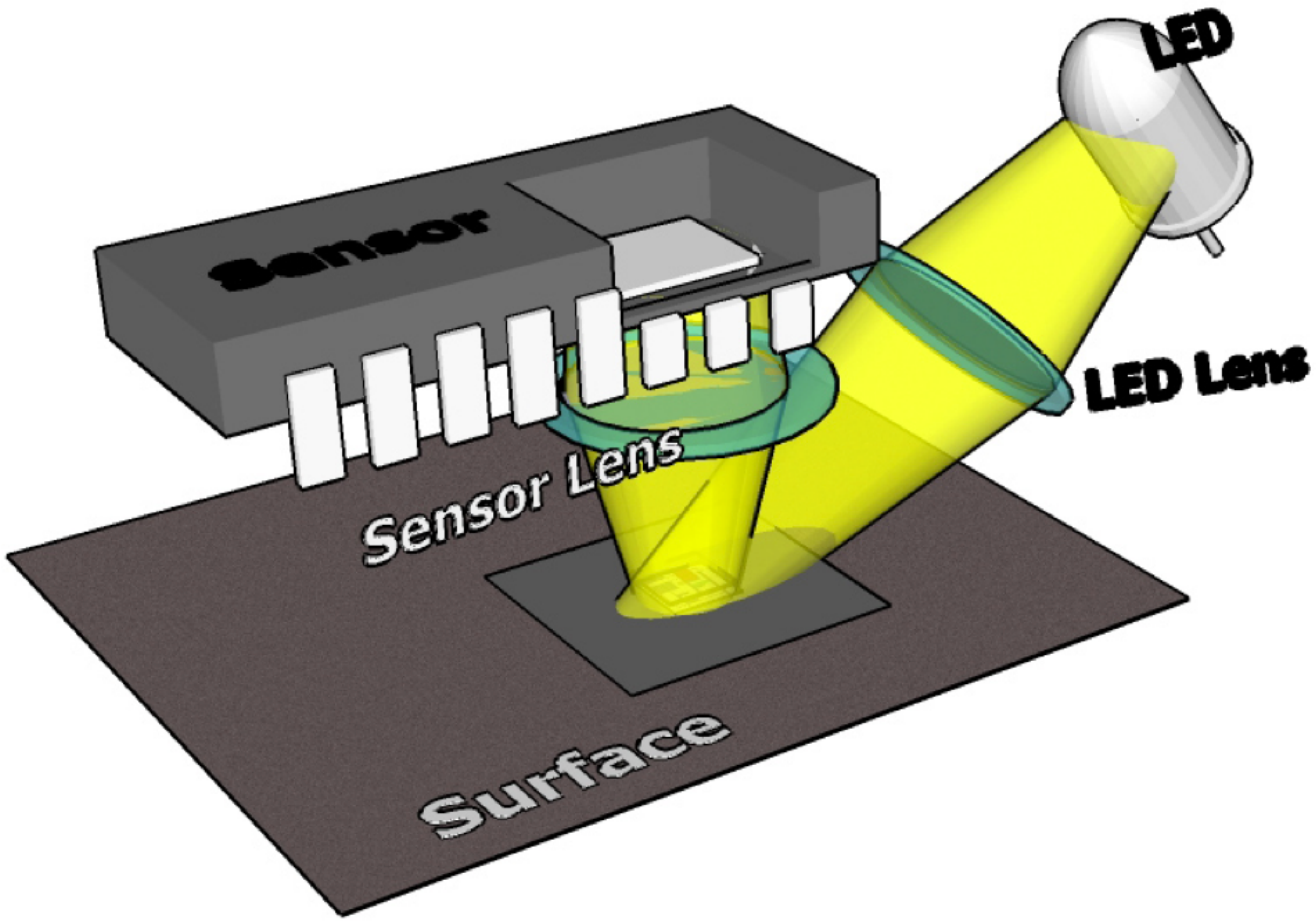

W
D

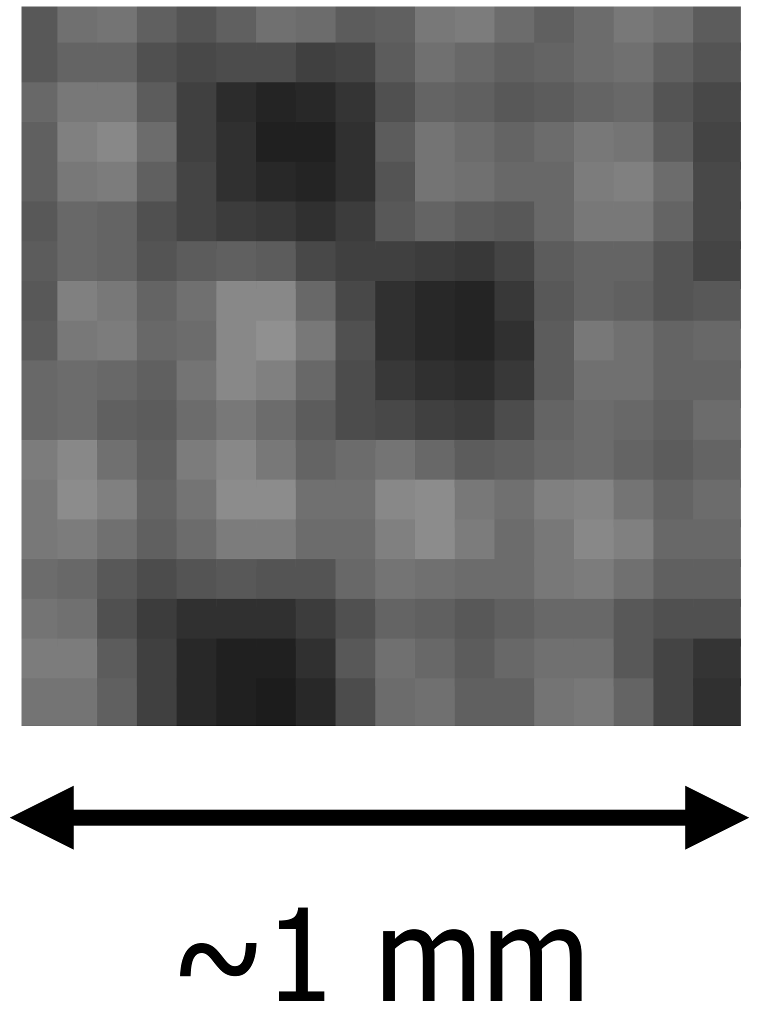
Gain constants

$$CD_{\min} = \frac{\boxed{D_{\max}}}{\boxed{OR_{\max}}} \qquad CD_{\max} = \min\left(CD_{q\max} = \boxed{\frac{Mouse_{res}(DPI)}{Screen_{res}(DPI)}}, CD_{l\max} = \frac{\boxed{W_{\min}}}{\boxed{Hand_{res}}} \right)$$

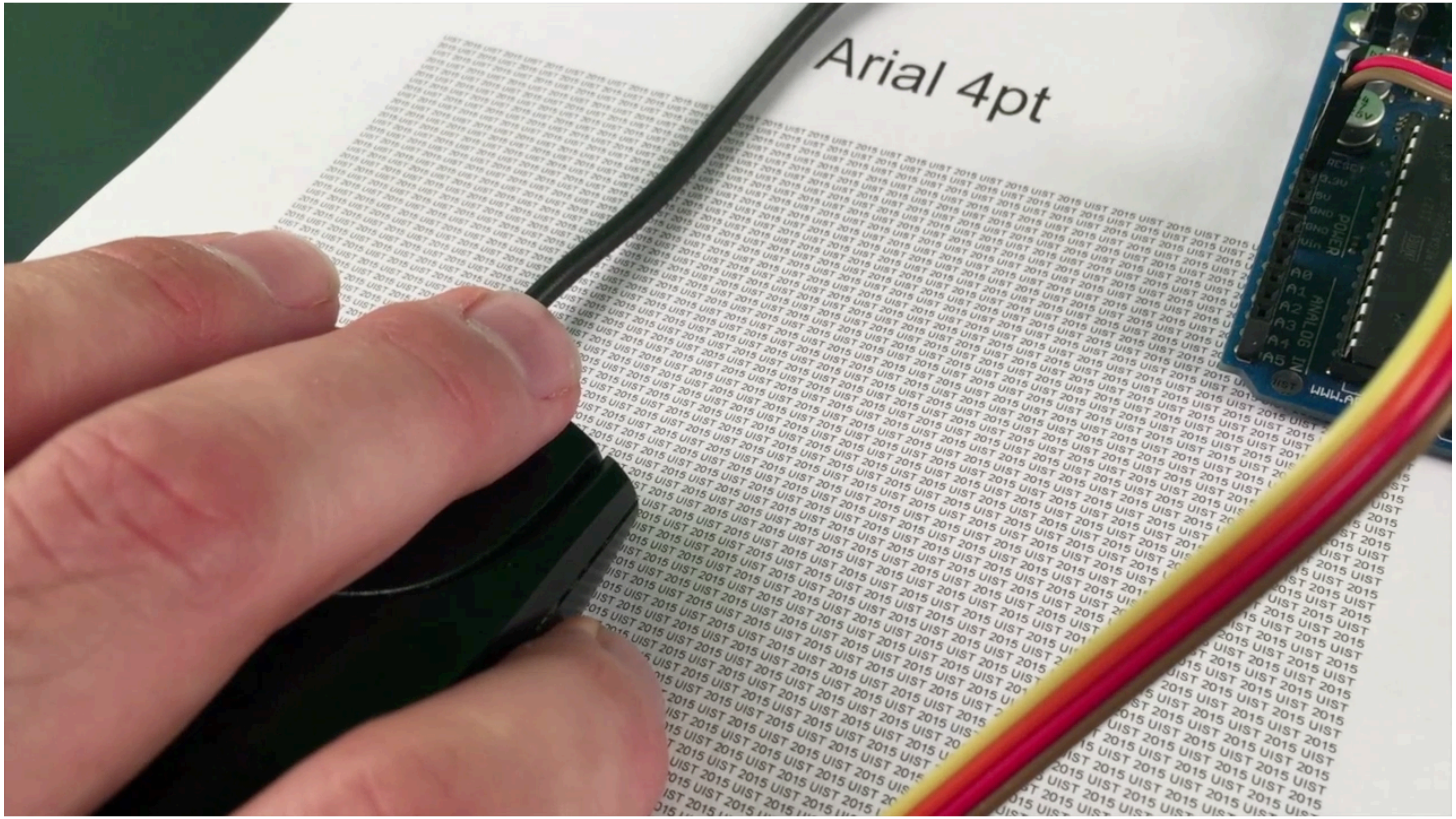
[Casiez et al. 2008]

Résolution





Caméra d’une souris



Résolution

400 CPI
~64 micromètres

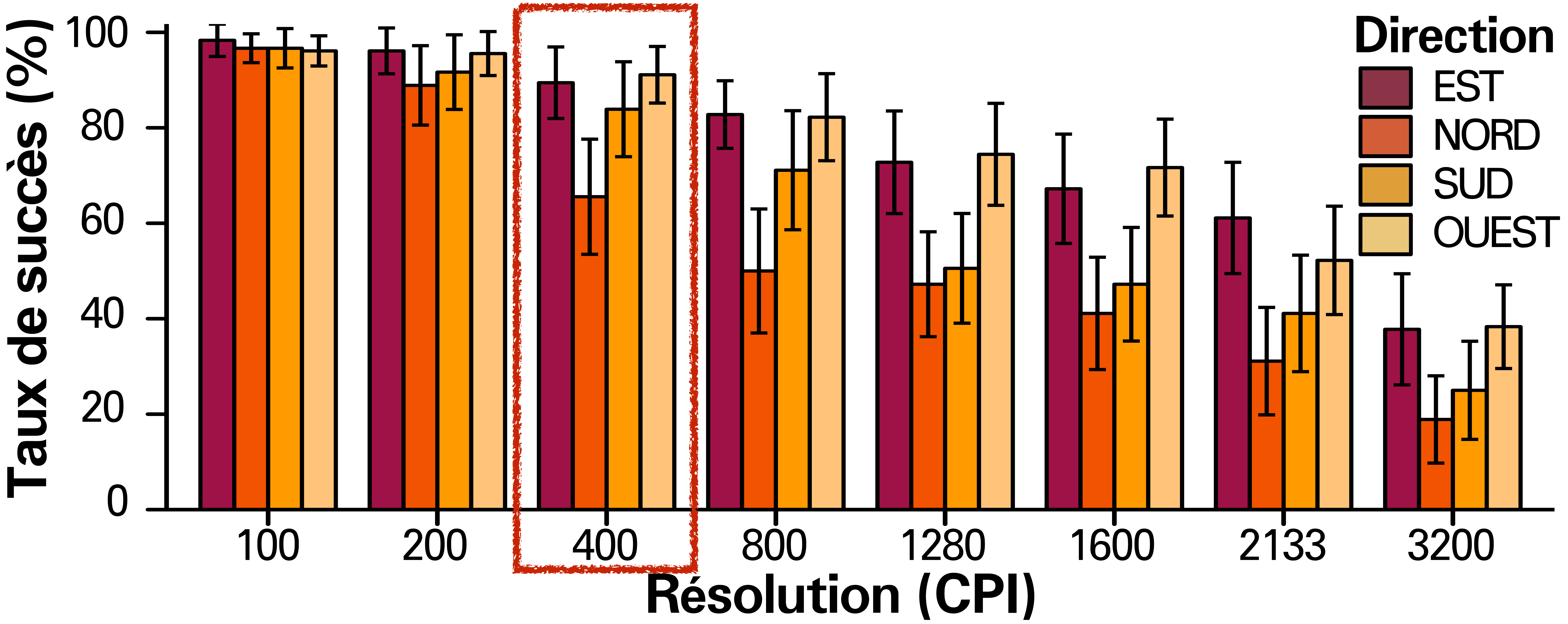
20 000 CPI
~1 micromètre

“*La* ***résolution utile*** *correspond au plus petit déplacement qu’un utilisateur peut produire de manière fiable avec une souris.*”

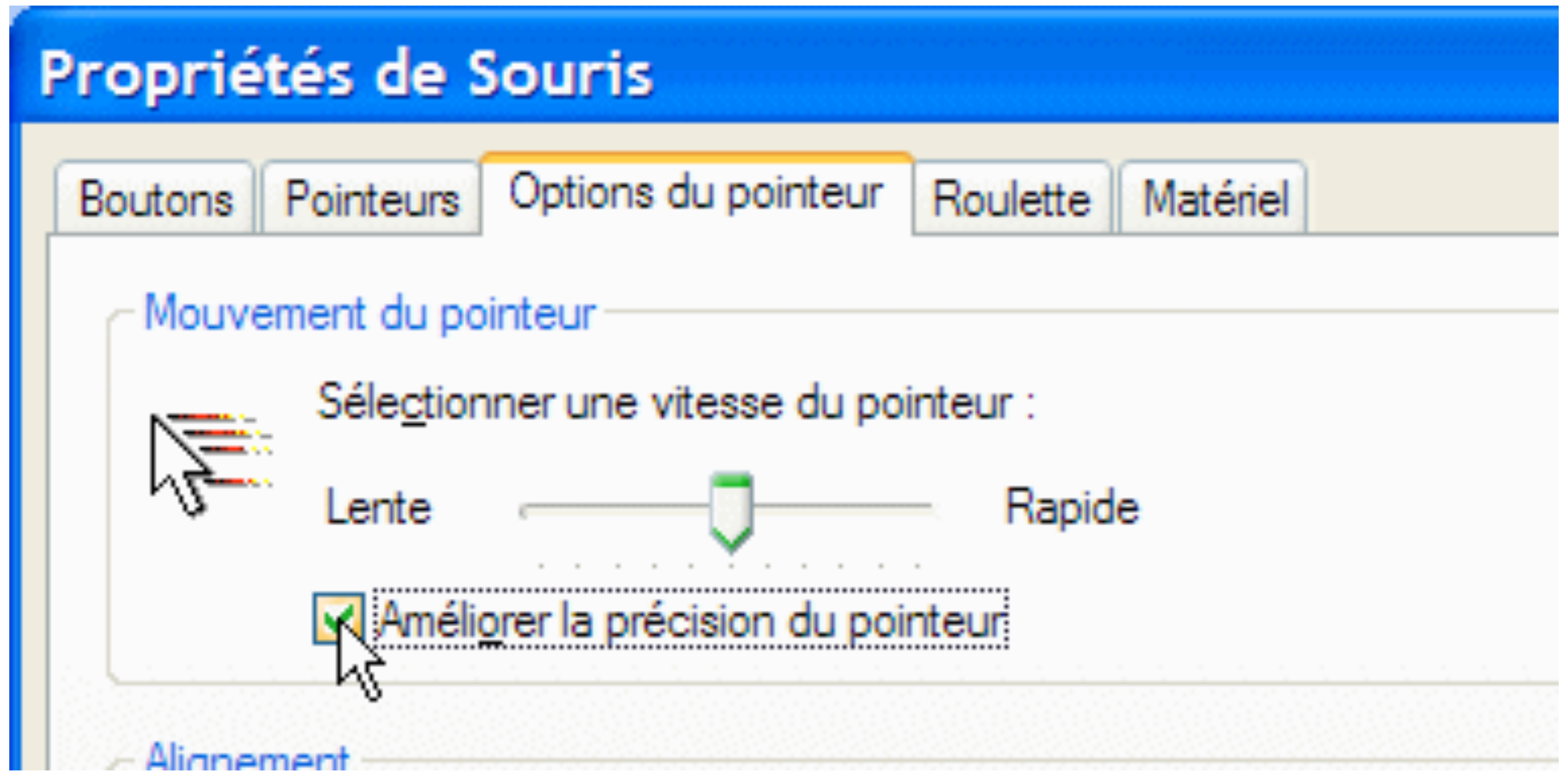
0

$\rightarrow \qquad \leq \mathbf{63}$

[Aceituno et al. 2013]

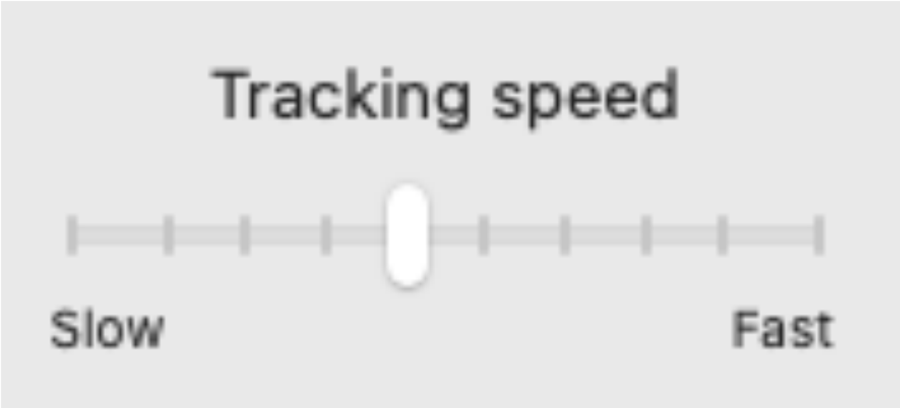


[Aceituno et al. 2013]

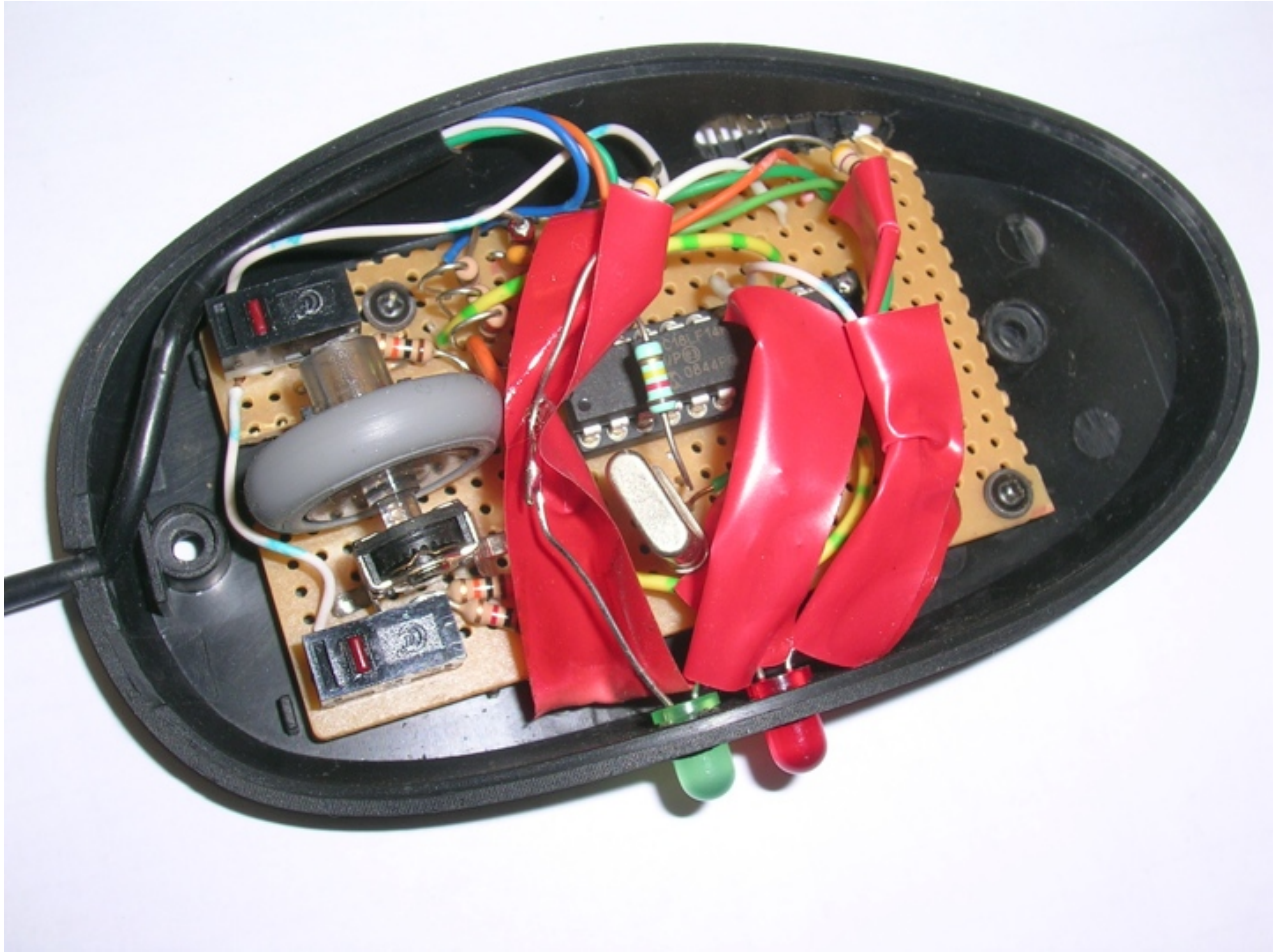


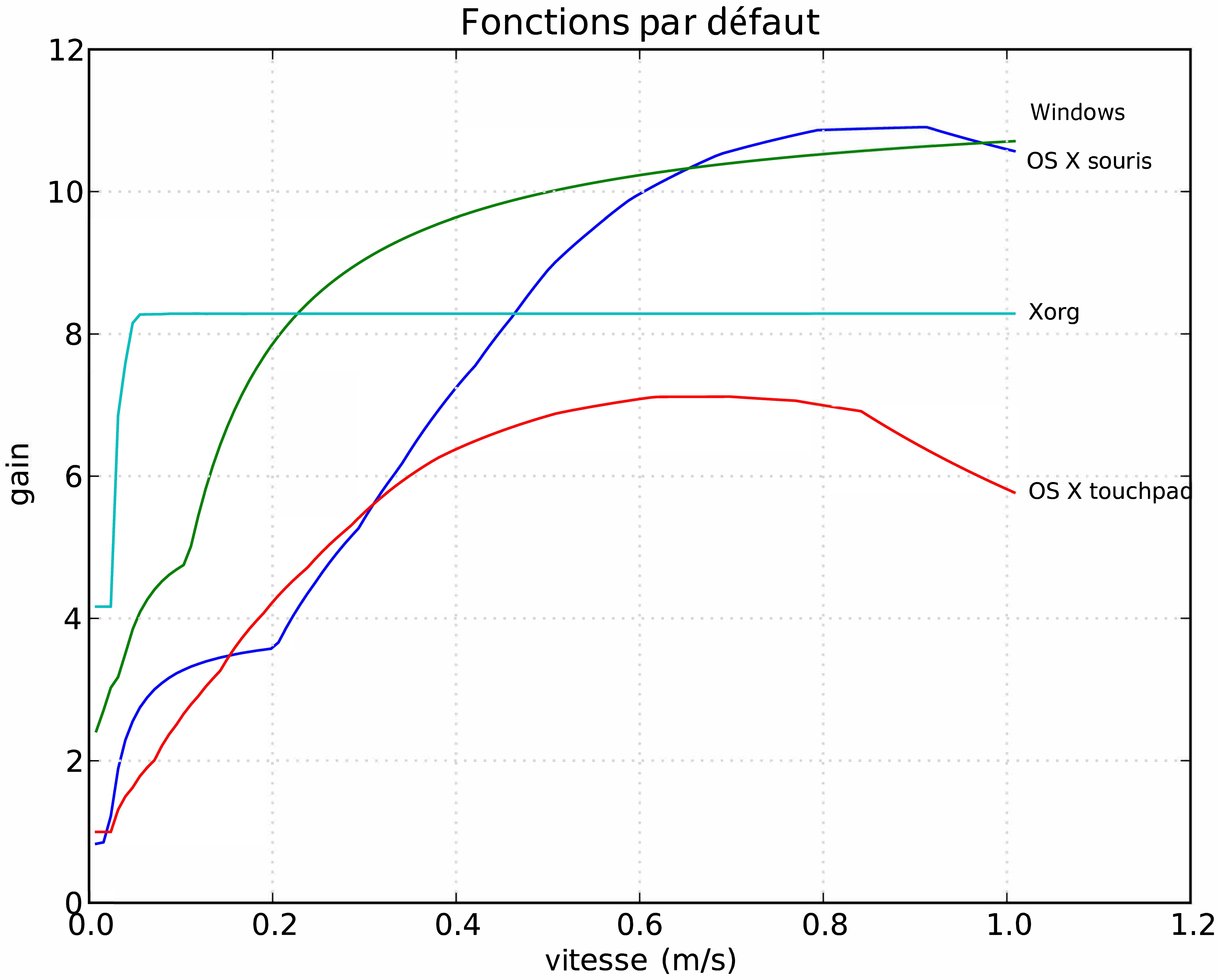
Windows

Linux



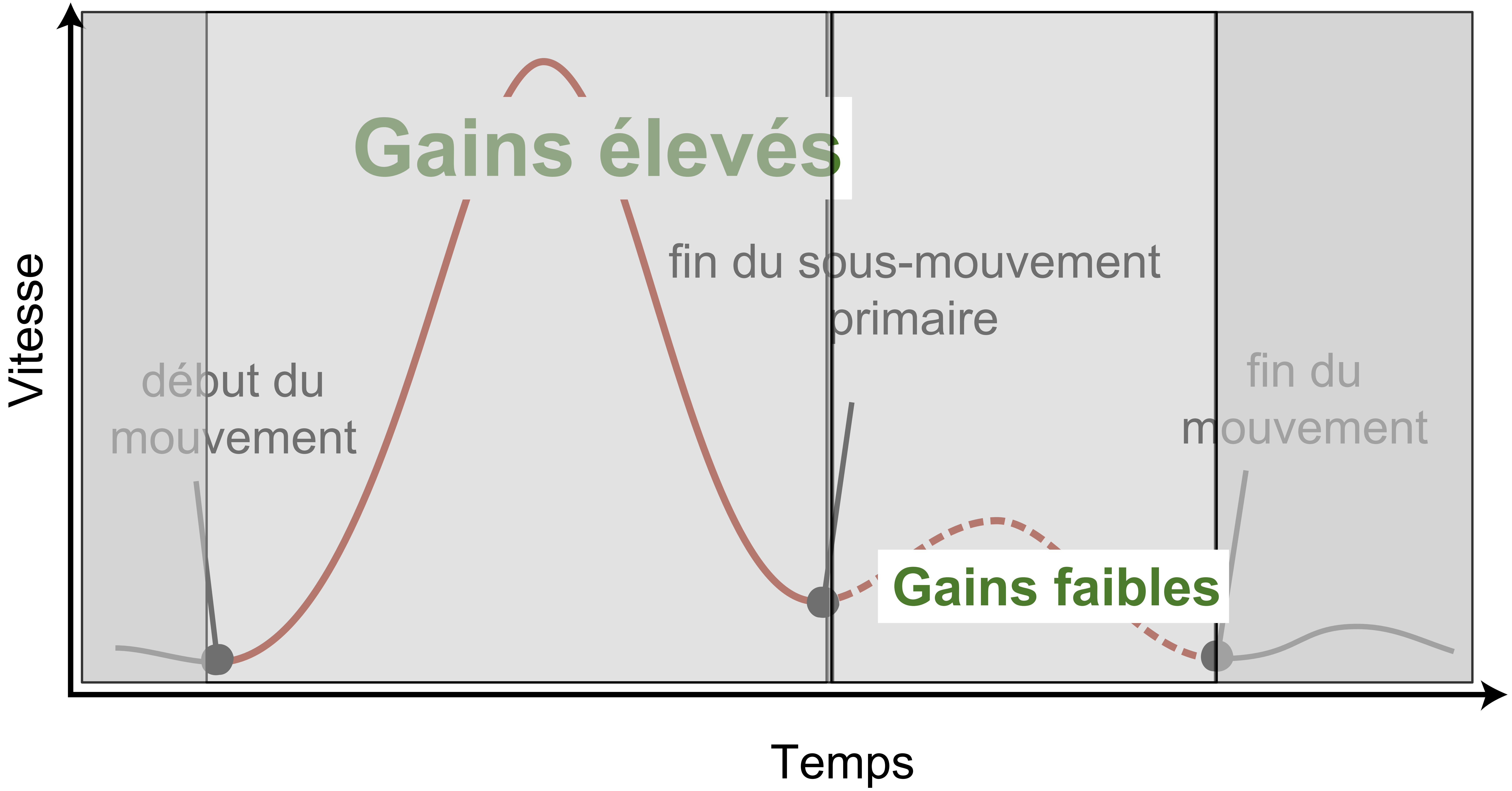
Mac




Fonctions par défaut
Windows
OS X souris
Xorg
OS X touchpad
gain
vitesse (m/s)
0
2
4
6
8
10
12
0.0
0.2
0.4
0.6
0.8
1.0
1.2

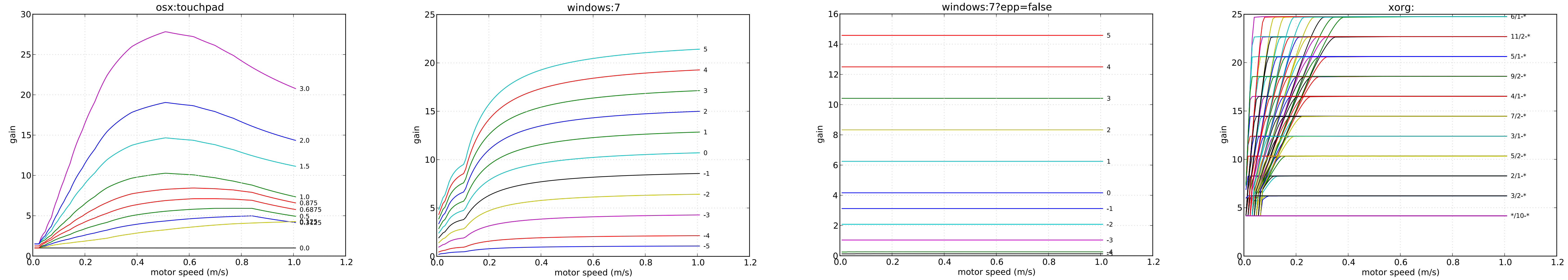
constant:?cdgain=1.5
xorg:
osx:mouse
windows:7

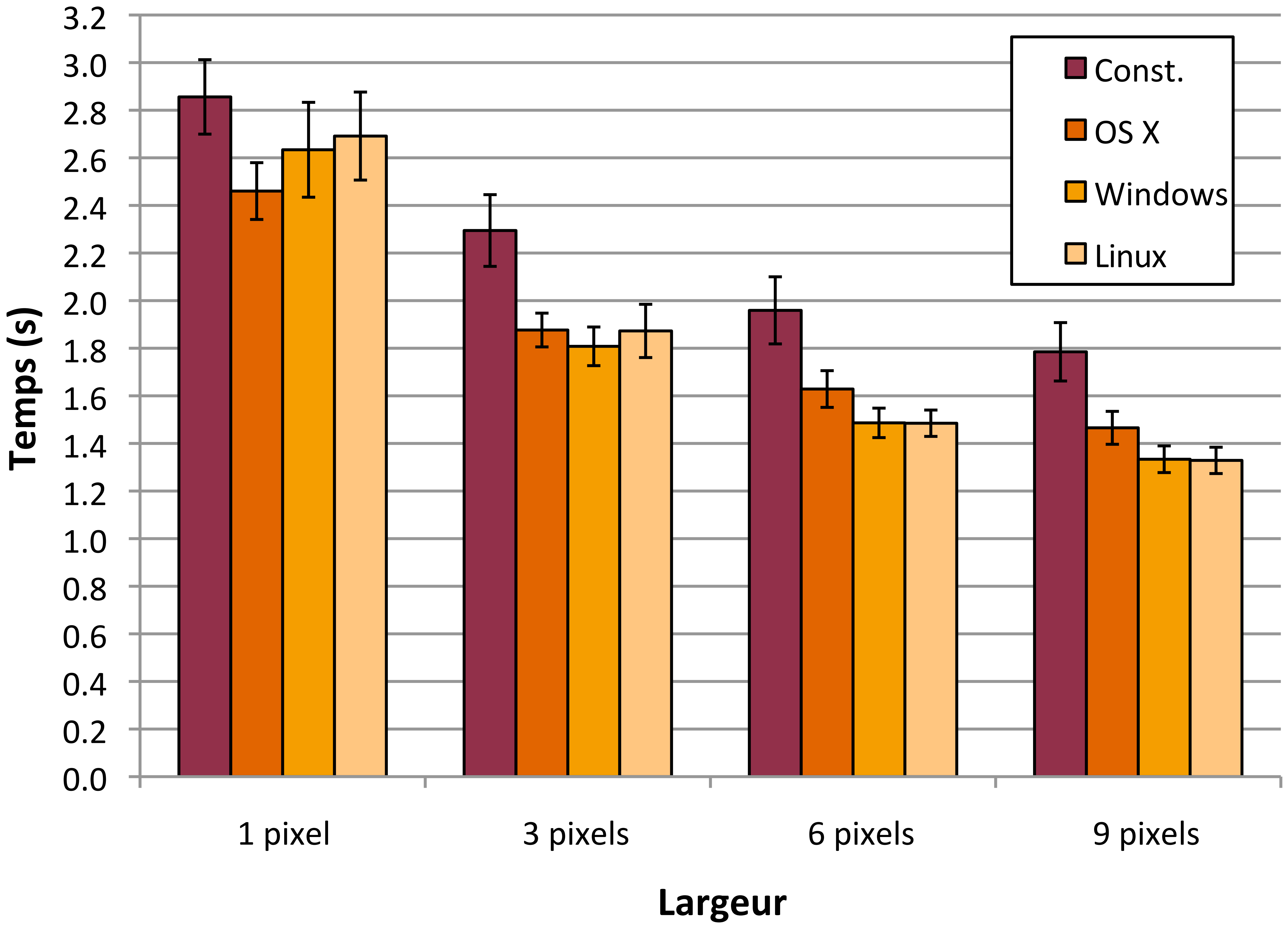
Fonctions non linéaires



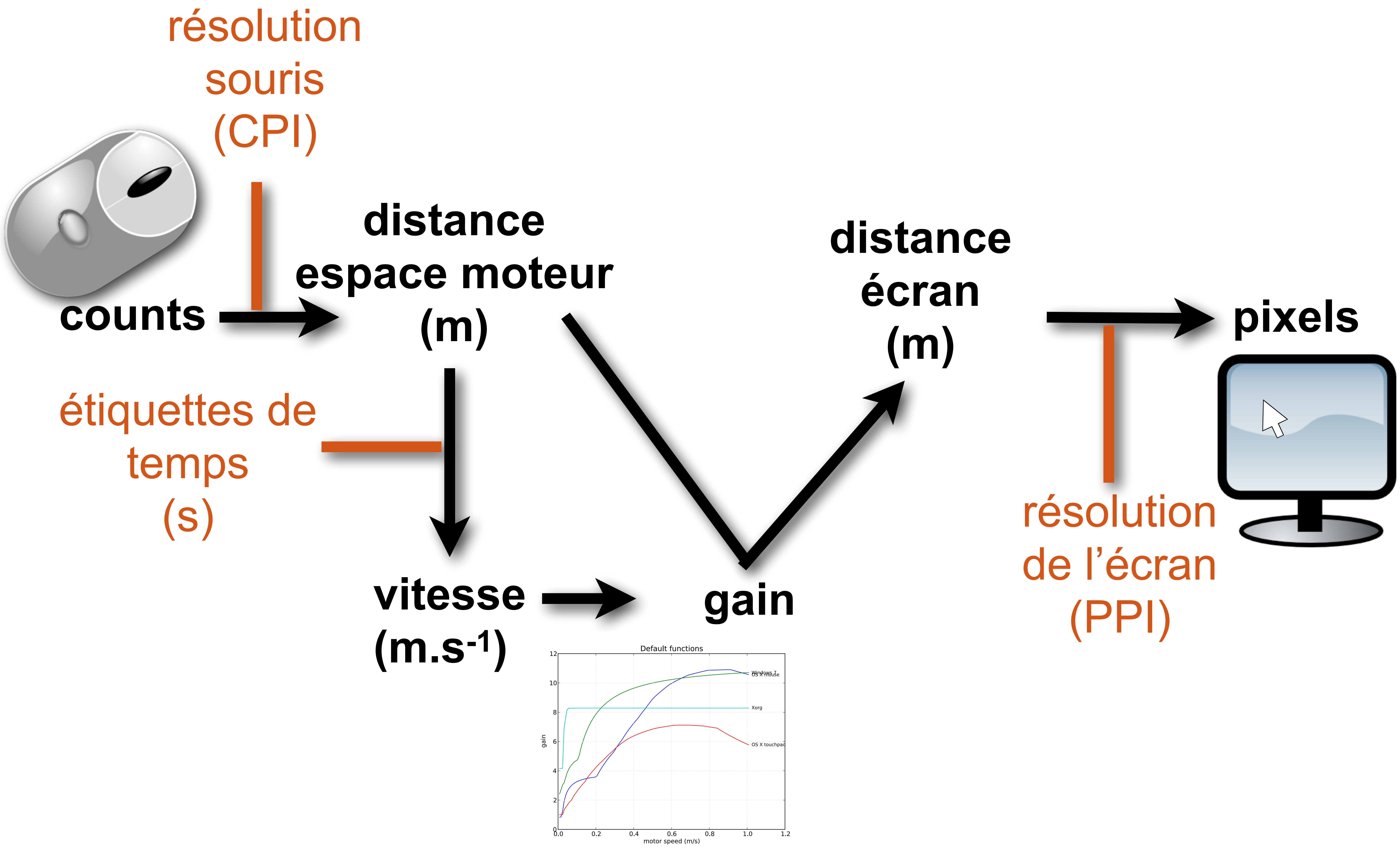
Modèle de l'impulsion initiale optimisée [Meyer et al.]

http://libpointing.org





[Casiez & Roussel 2011]


résolution
souris
(CPI)
counts
distance
espace moteur
(m)
étiquettes de
temps
(s)
vitesse
(m.s-1)
gain
Default functions
gain
motor speed (m/s)
Windows 7
OS X mouse
Xorg
OS X touchpad
distance
écran
(m)
pixels
résolution
de l'écran
(PPI)

ns.inria.fr/loki/tftools

Educate your computer mouse

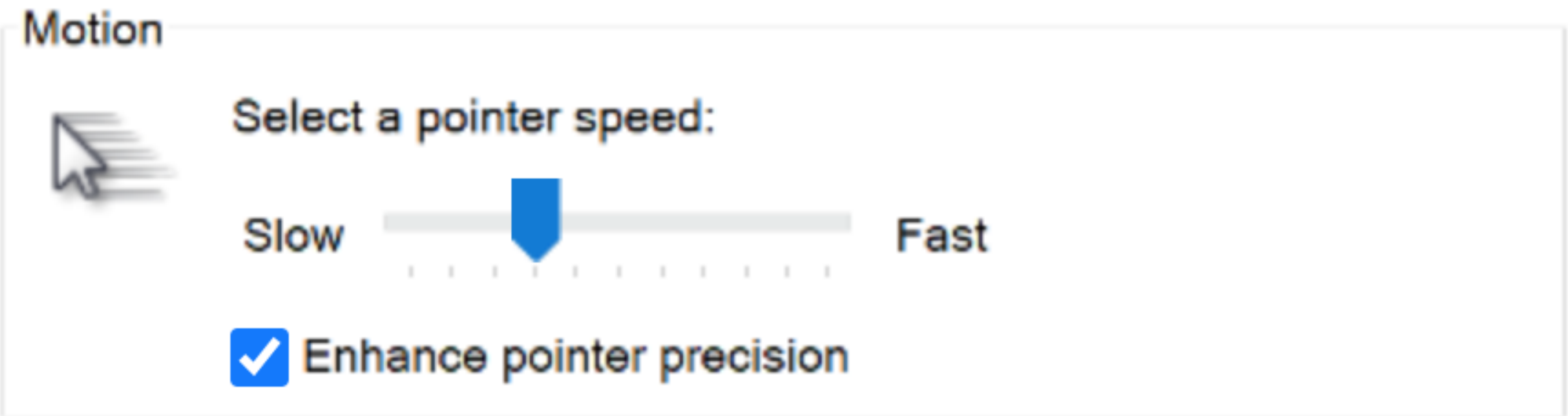
This tool helps you adjust the mouse settings in the configuration panel to mimic the cursor behavior you have on another computer with different computer mouse/monitor.

STEP 1: fill the information below

Configuration of the computer with the cursor behavior you want to mimick

Mouse resolution (CPI or DPI)	1200
Mouse input frequency (Hz)	125
Display pixel density (DPI)	87

Adjust the slider and checkbox below to replicate exactly what appears in the mouse configuration panel

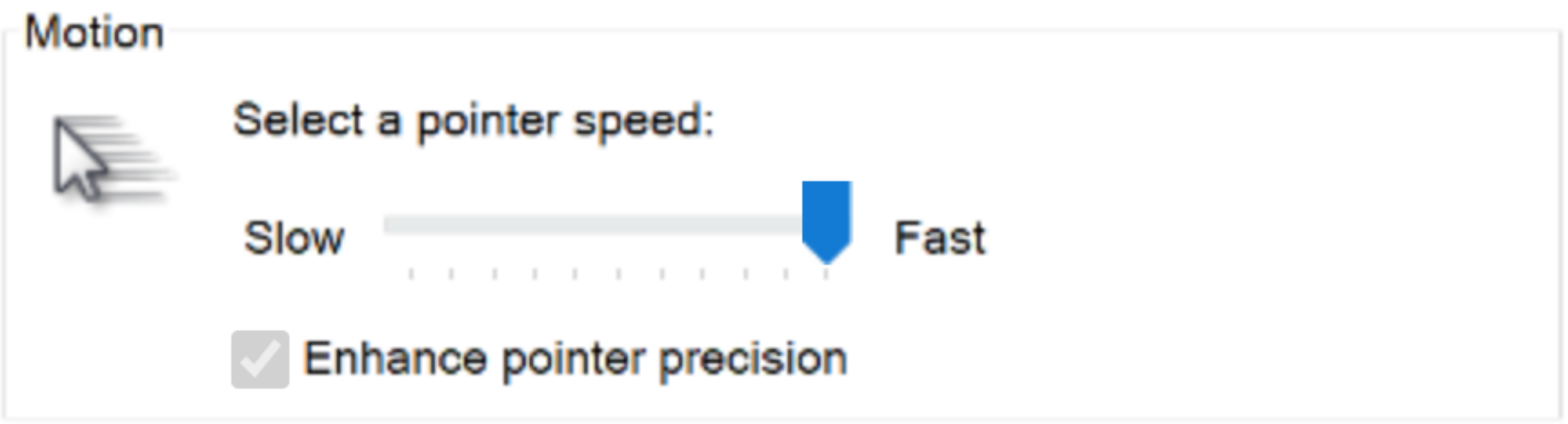


STEP 2: fill the information below to get the setting to set for your mouse

Configuration of the computer where you want to replicate the cursor behavior

Mouse resolution (CPI or DPI)	800
Mouse input frequency (Hz)	125
Display pixel density (DPI)	298

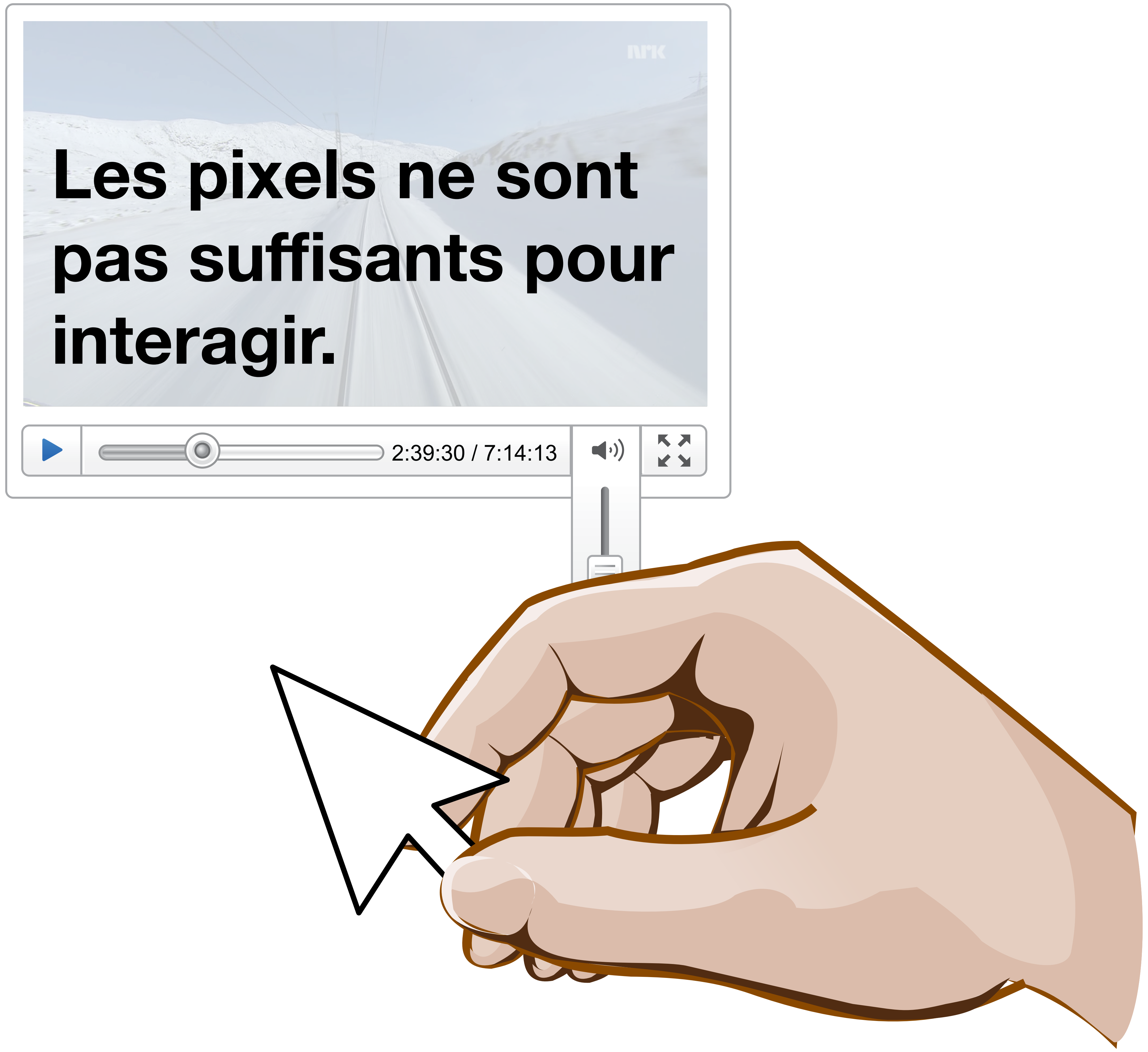
STEP 3: go in your mouse configuration panel and adjust the settings as follows



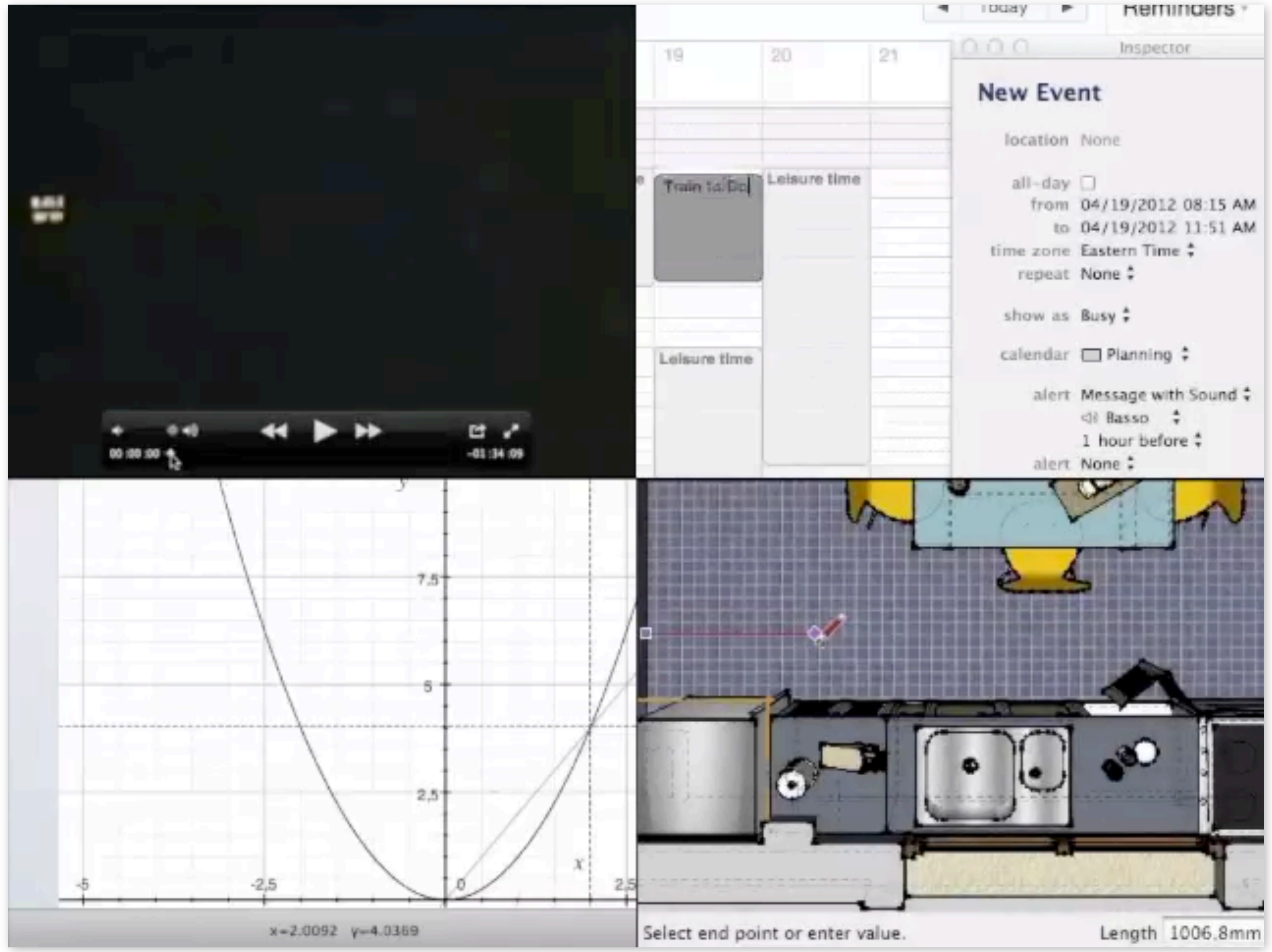
[Hanada et al. 2021]

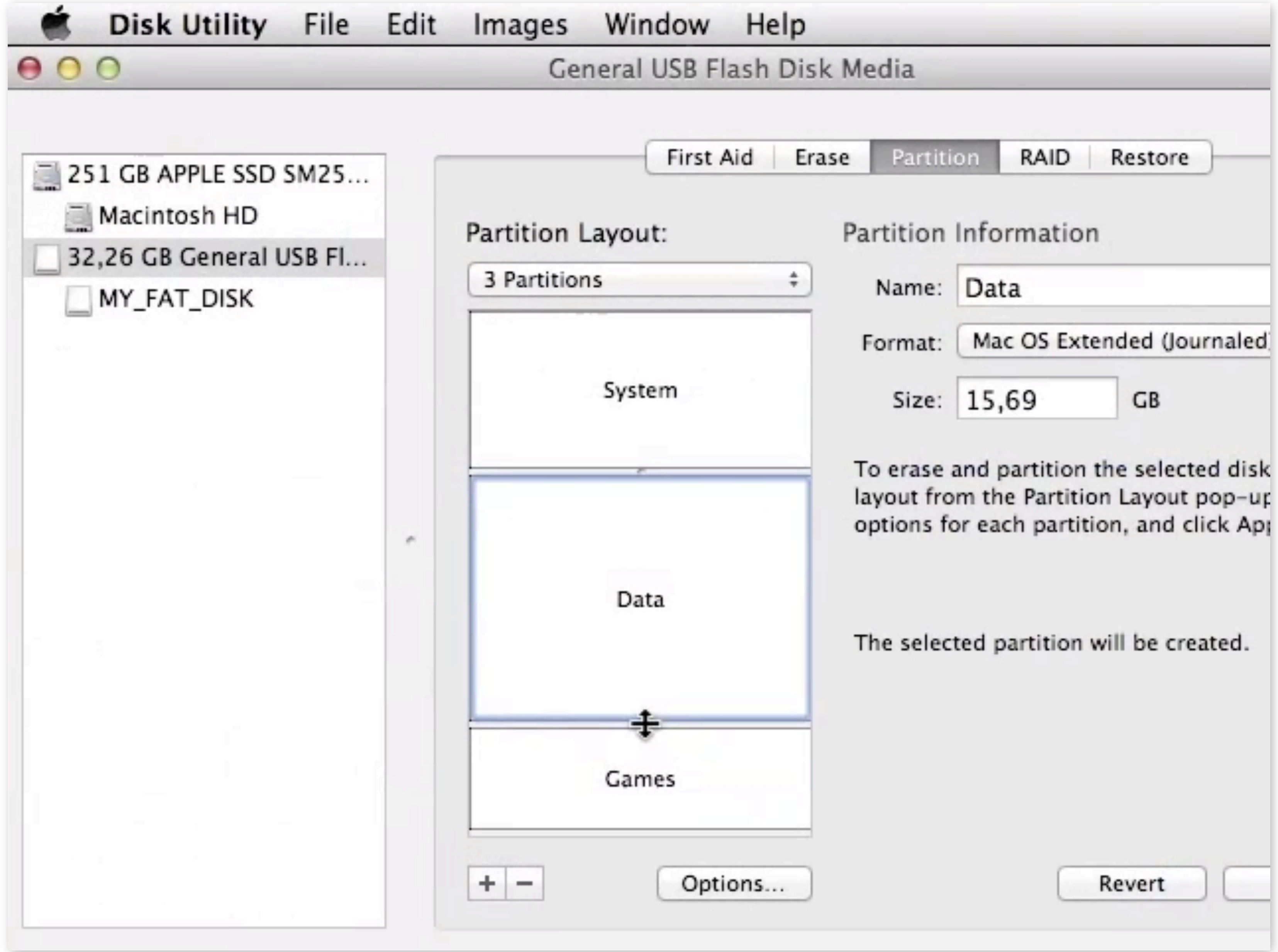
“Bergensbanen” - NRK

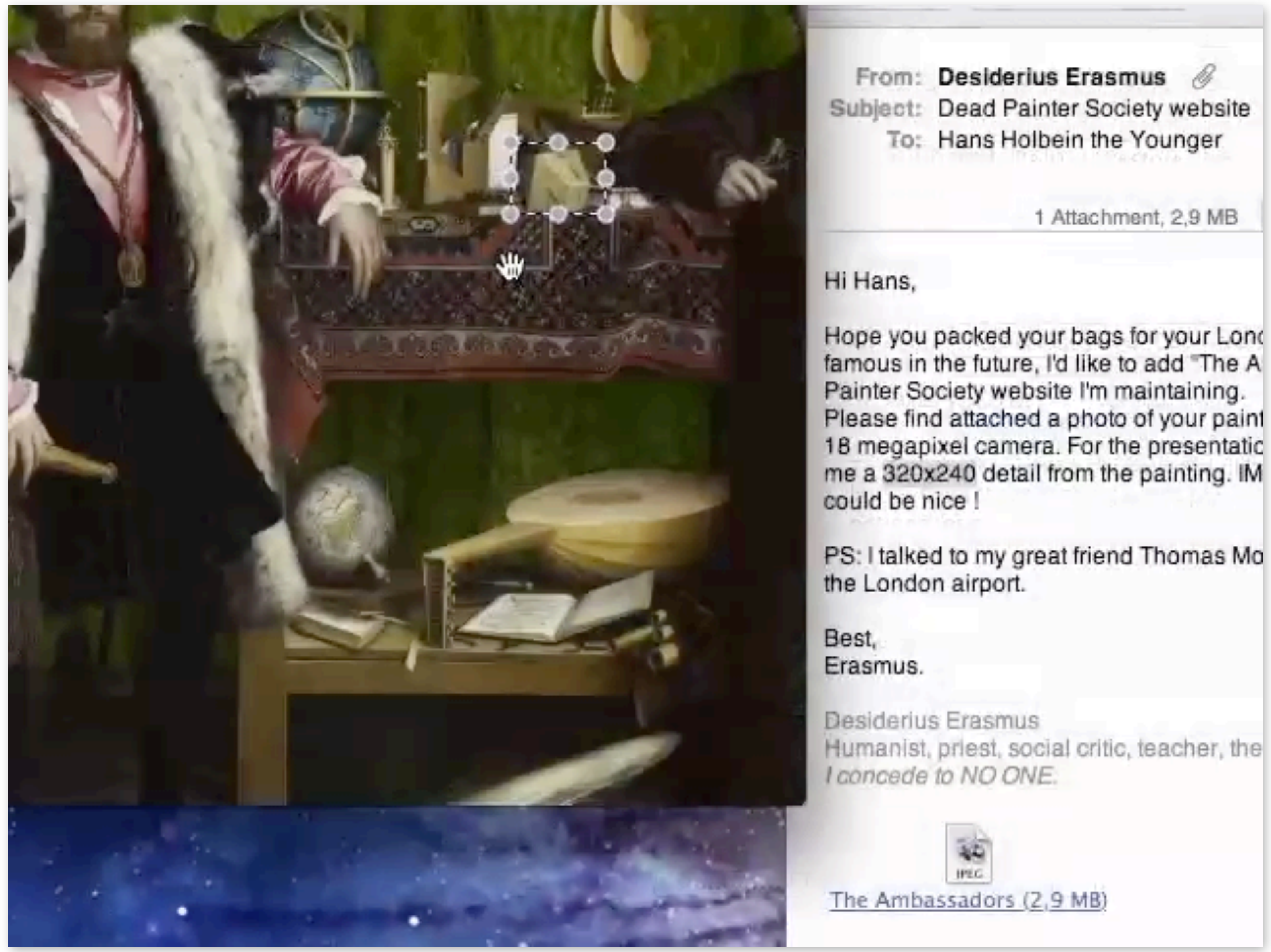
7:14:13 ➟ 26 053 secondes ➟ 1 302 650 frames




Tue 22

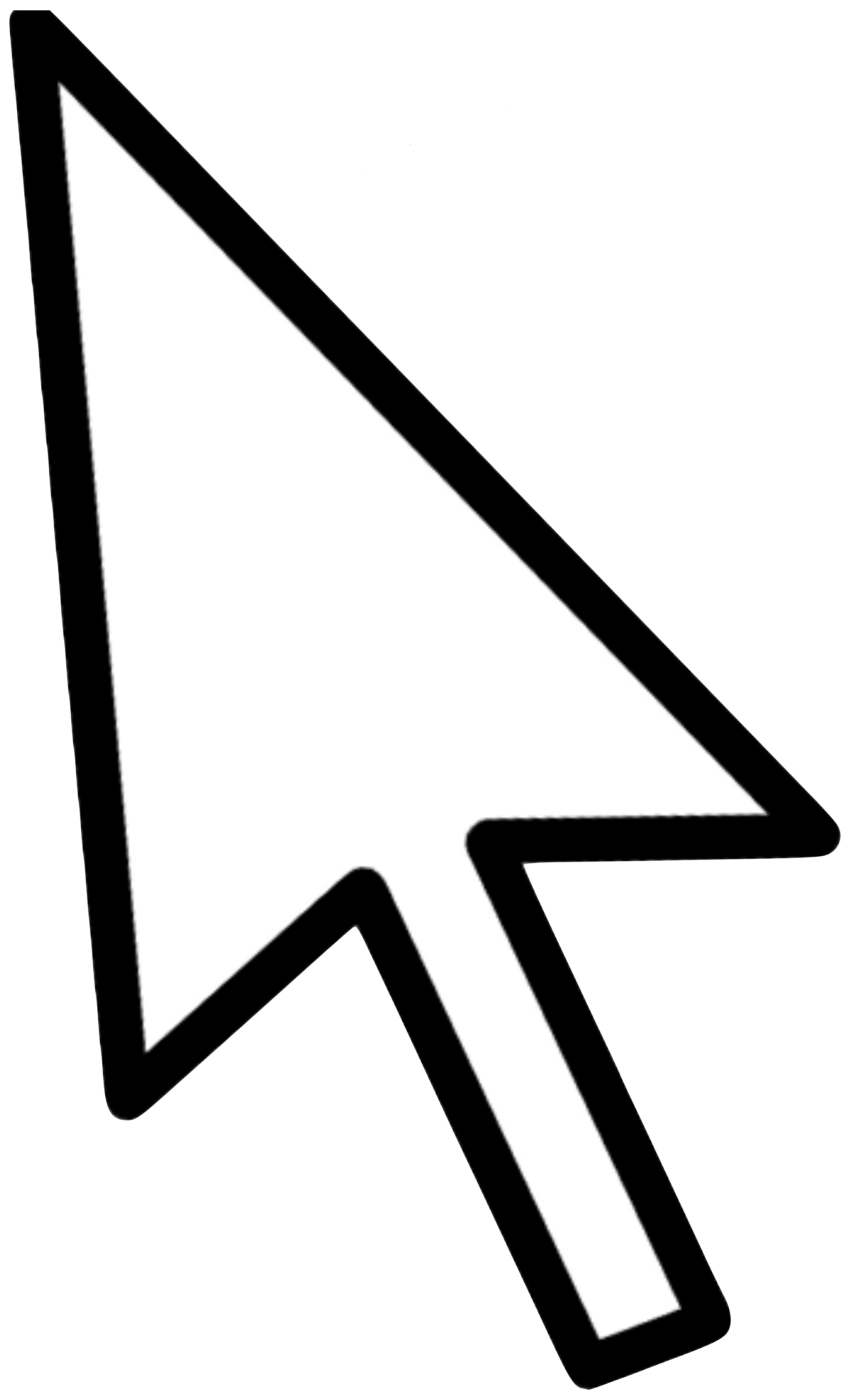

New Event
location None
all-day
from 04/19/2012 08:15 AM
to 04/19/2012 11:51 AM
time zone Eastern Time
repeat None
show as Busy
calendar Planning
alert Message with Sound
Basso
1 hour before
alert None
Leisure time
Select end point or enter value.
Length 1006,8mm

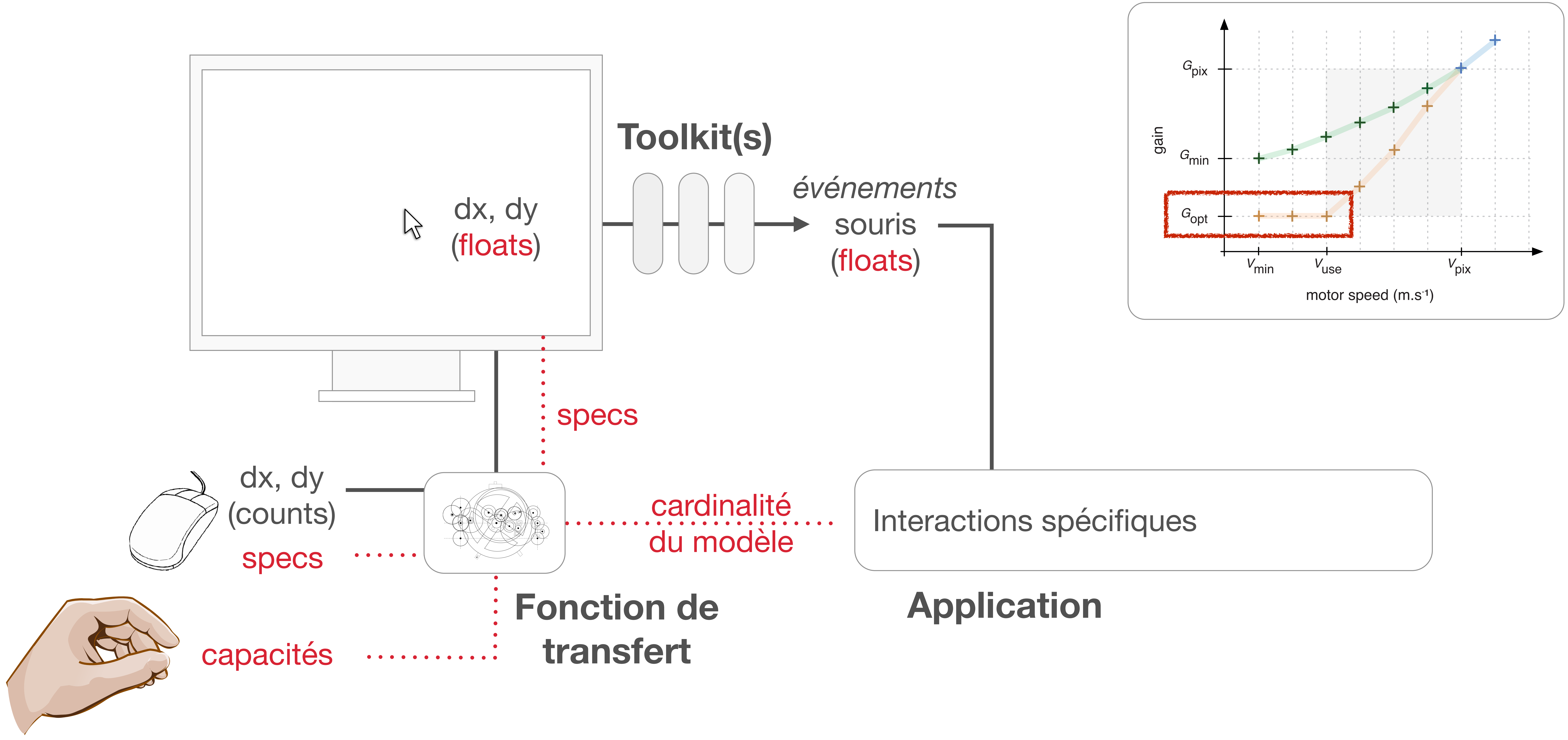

Disk Utility File Edit Images Window Help
General USB Flash Disk Media
251 GB APPLE SSD SM25...
Macintosh HD
32,26 GB General USB Fl...
MY_FAT_DISK
First Aid
Erase
Partition
RAID
Restore
Partition Layout:
3 Partitions
System
Data
Games
Partition Information
Name: Data
Format: Mac OS Extended (Journaled
Size: 15,69 GB
The selected partition will be created.
Options...
Revert


From: Desiderius Erasmus
Subject: Dead Painter Society website
To: Hans Holbein the Younger
1 Attachment, 2,9 MB
Hi Hans,
Hope you packed your bags for your Lond
famous in the future, I'd like to add "The A
Painter Society website I'm maintaining.
Please find attached a photo of your paint
18 megapixel camera. For the presentatic
me a 320x240 detail from the painting. IM
could be nice !
PS: I talked to my great friend Thomas Mo
the London airport.
Best,
Erasmus.
Desiderius Erasmus
Humanist, priest, social critic, teacher, the
I concede to NO ONE.
The Ambassadors (2,9 MB)


1 Bass
2 Drums
A Return
B Return
Master
Bass1
Stop Clips
Sends
Post
Impulse
Start
Transp
Stretch
Drive
Freq
Res
Decay
Pan
Volume


Overview
Visits vs. Select a metric
Visits
200
100
Friday, September 12, 2008
Visits: 8
Jul 2008
Jan 2009
Jul 2009
Jan 2010
8,274 people visited this site
10,120 Visits
8,274 Unique Visitors
12,611 Pageviews
1.25 Pages/Visit





[Roussel et al. 2012]

Demonstration

SMITH, R.B. Experiences with the alternate reality kit: an example of the tension between literalism and magic. In *Proceedings of the SIGCHI/GI conference on Human factors in computing systems and graphics interface* (May 1987).

Slides

QuickTime

Start & Stop

00:00:00.00 00:07:21.61

Poster Frame

Start movie on click

Repeat

None

Volume

Controls

00:15:43.39 00:07:21.61

Slides

QuickTime

Start & Stop

00:00:00.00 00:07:21.61

Poster Frame

Start movie on click

Repeat

None

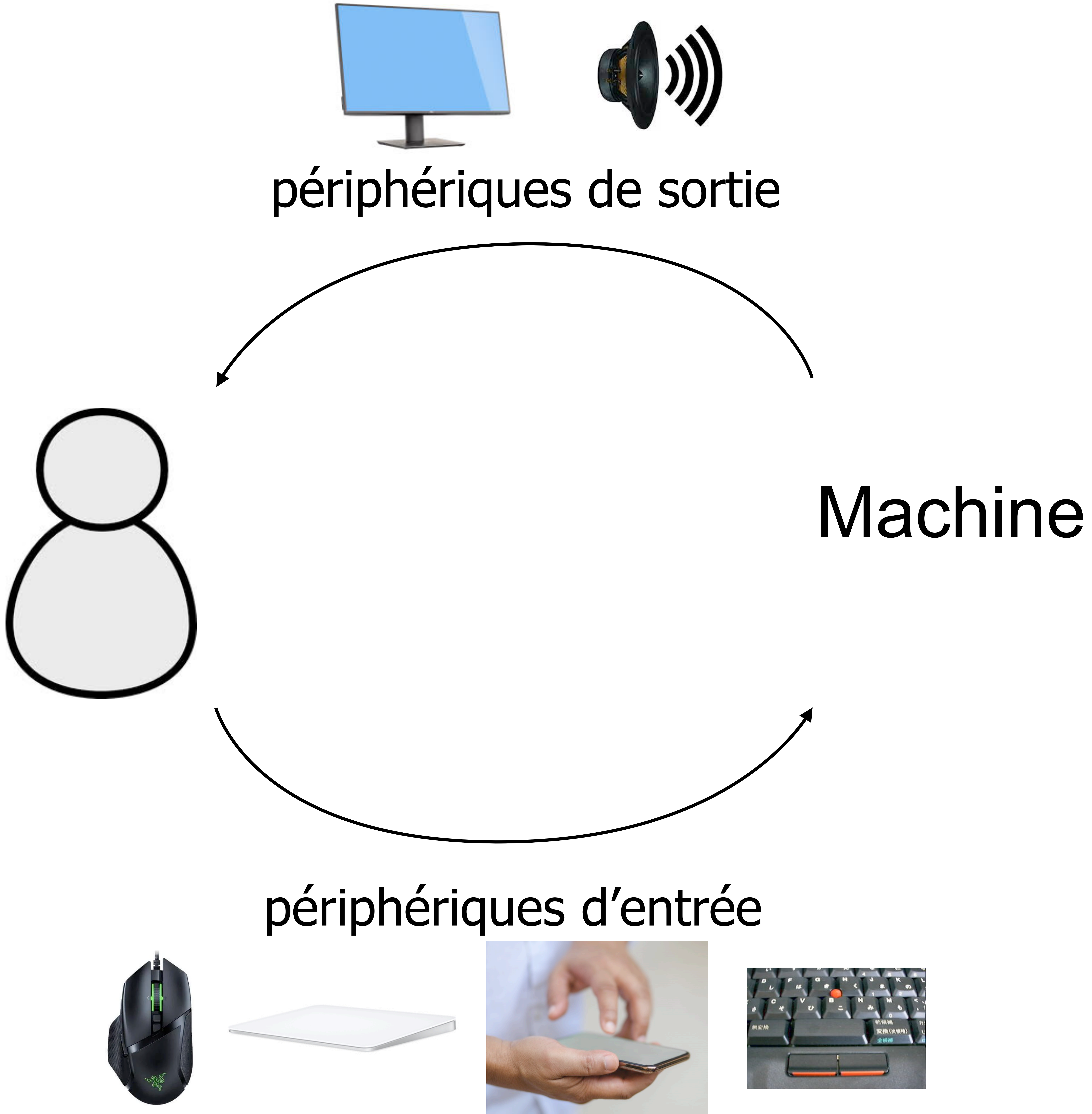
Volume

Controls

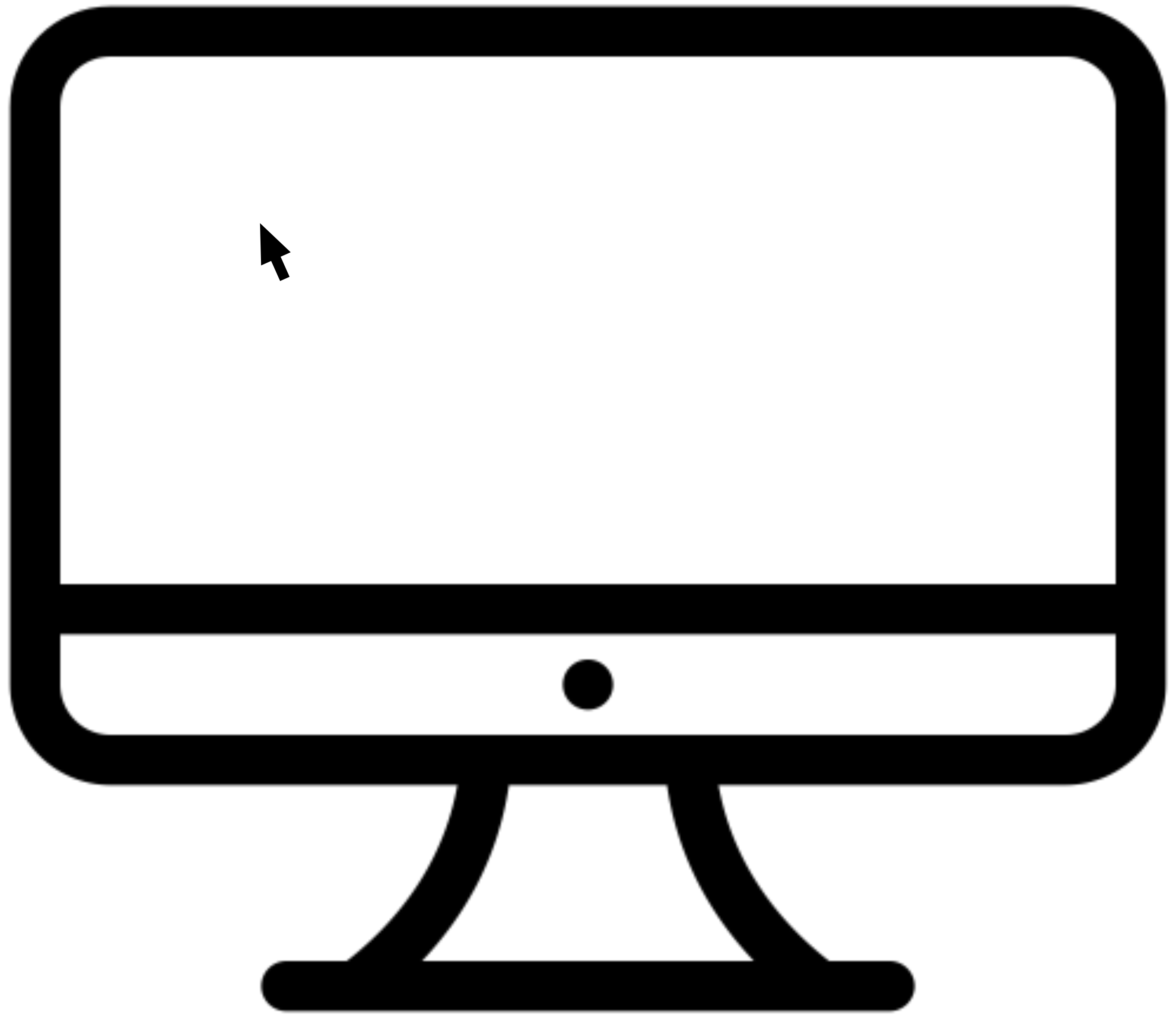
00:15:43.39 00:07:21.61

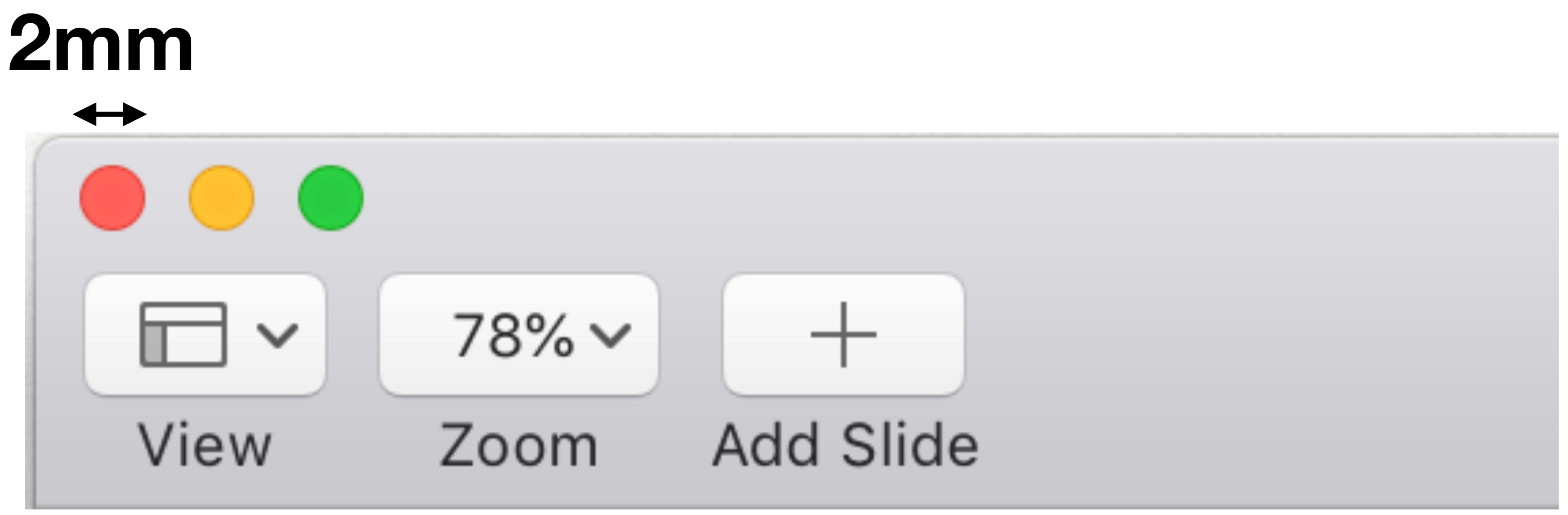
Demonstration

SMITH, R.B. Experiences with the alternate reality kit: an example of the tension between literalism and magic. In *Proceedings of the SIGCHI/GI conference on Human factors in computing systems and graphics interface* (May 1987).


périphériques de sortie
Machine
périphériques d'entrée

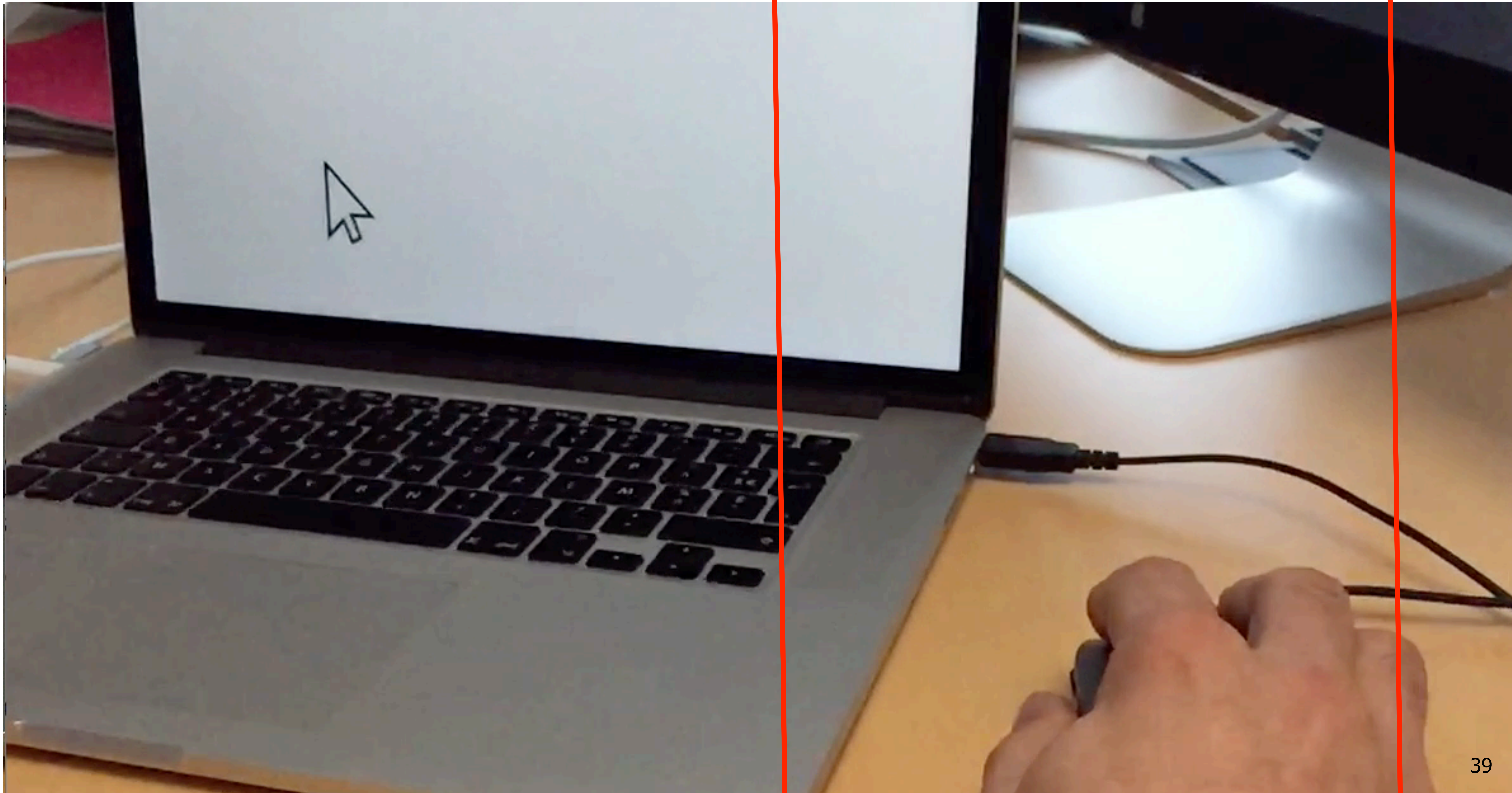
[Ng et al. 2012, Jota et al. 2013]



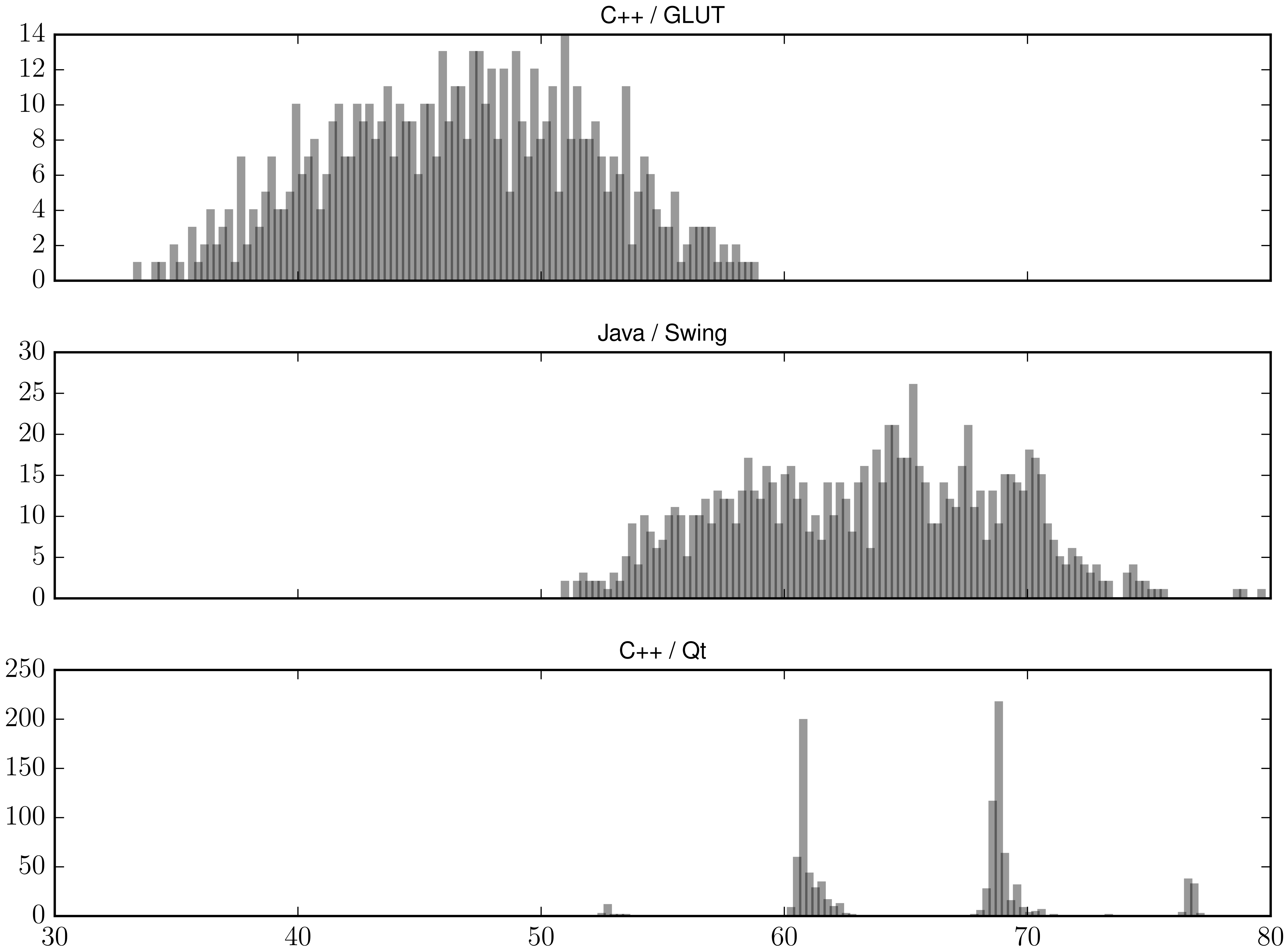


[MacKenzie et al. 93, Pavlovych et al. 09, Teather et al. 09, Pavlovych et al. 12, Claypool et al. 14]

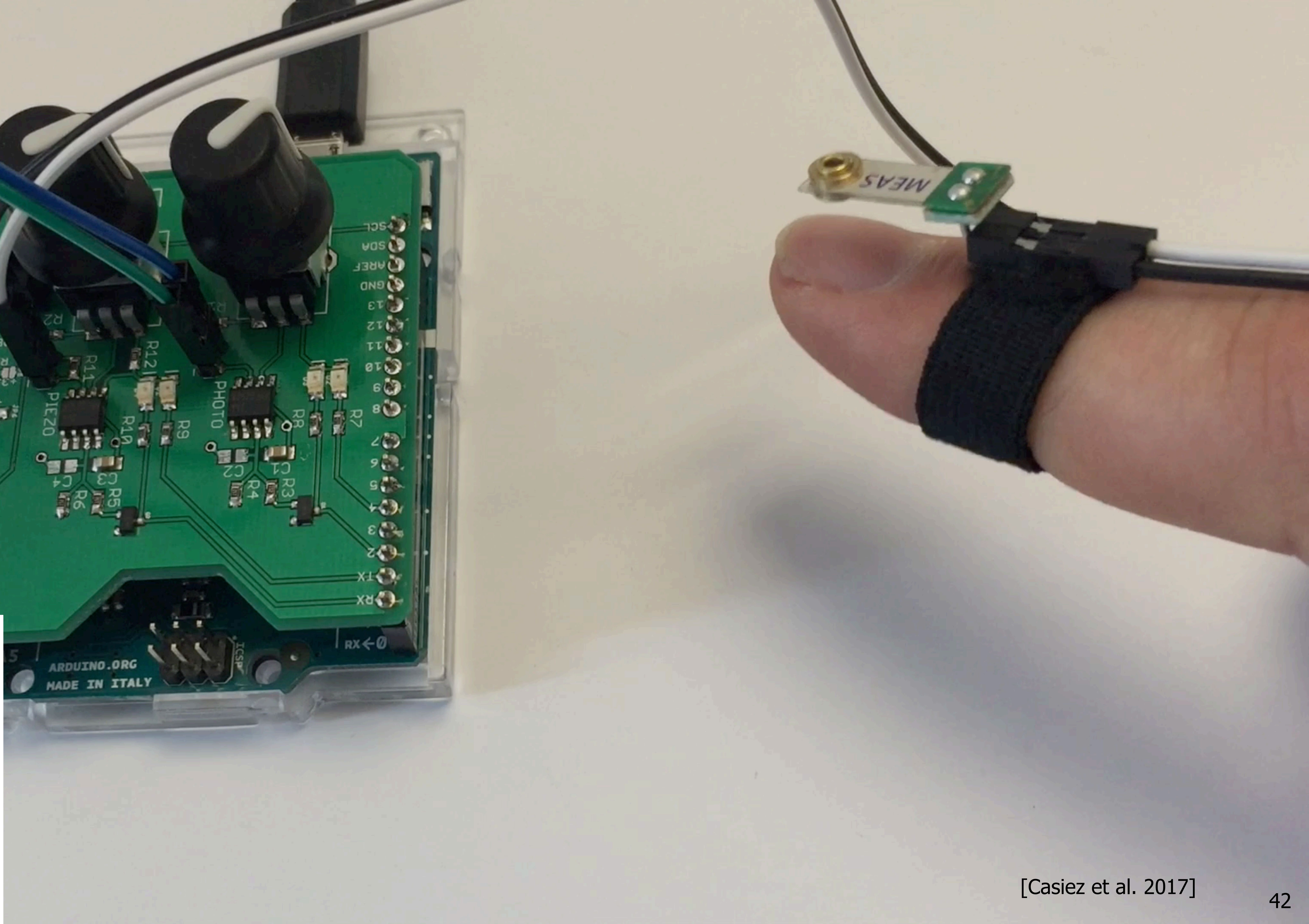
T_1 0 T_0

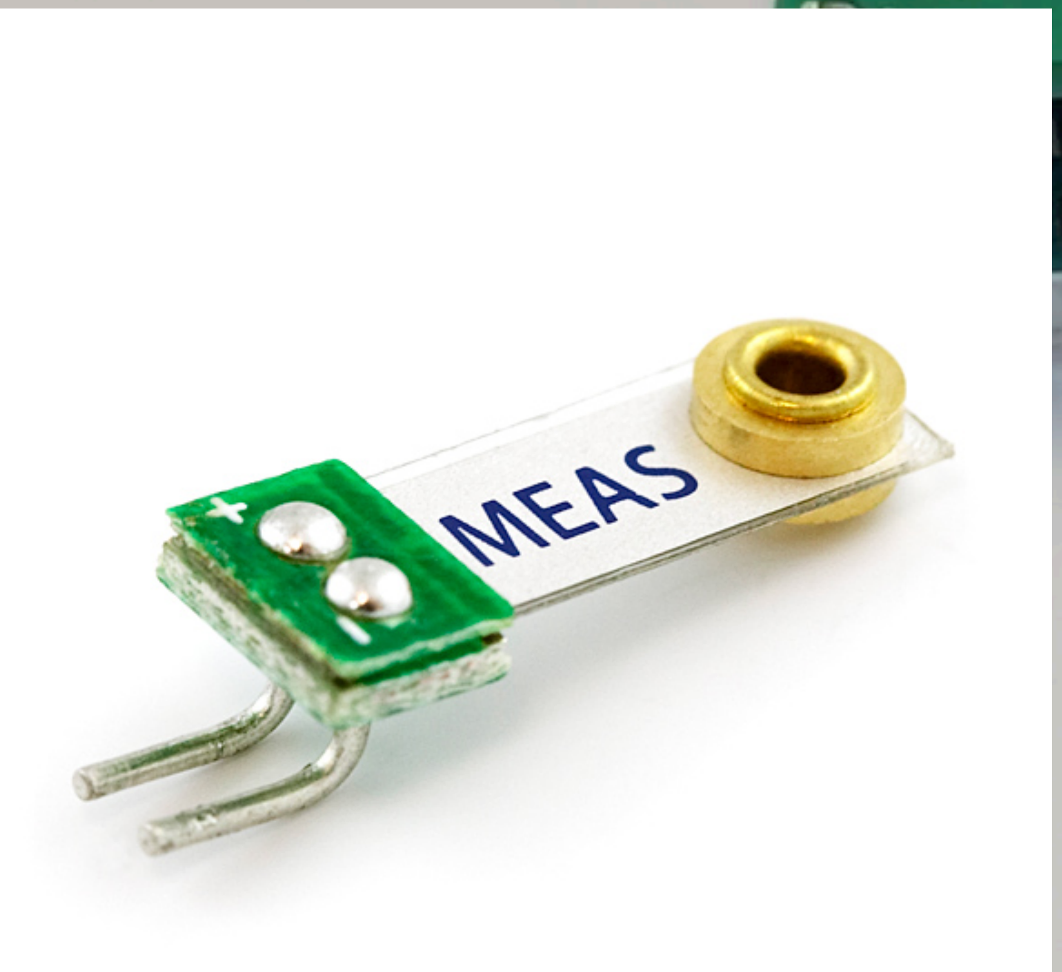



LagMeter
Fri 14:32
Lag Meter
Input device:
Logitech - USB-PS/2 C
Callback timeout (ms):
200
Stop
Statistics
Success rate 100 %
Mean successful measures per second 5
Mean lag (ms) 41.755
Std lag (ms) 1.82
min - max lag (ms) 1.239 - 191.15
DELL



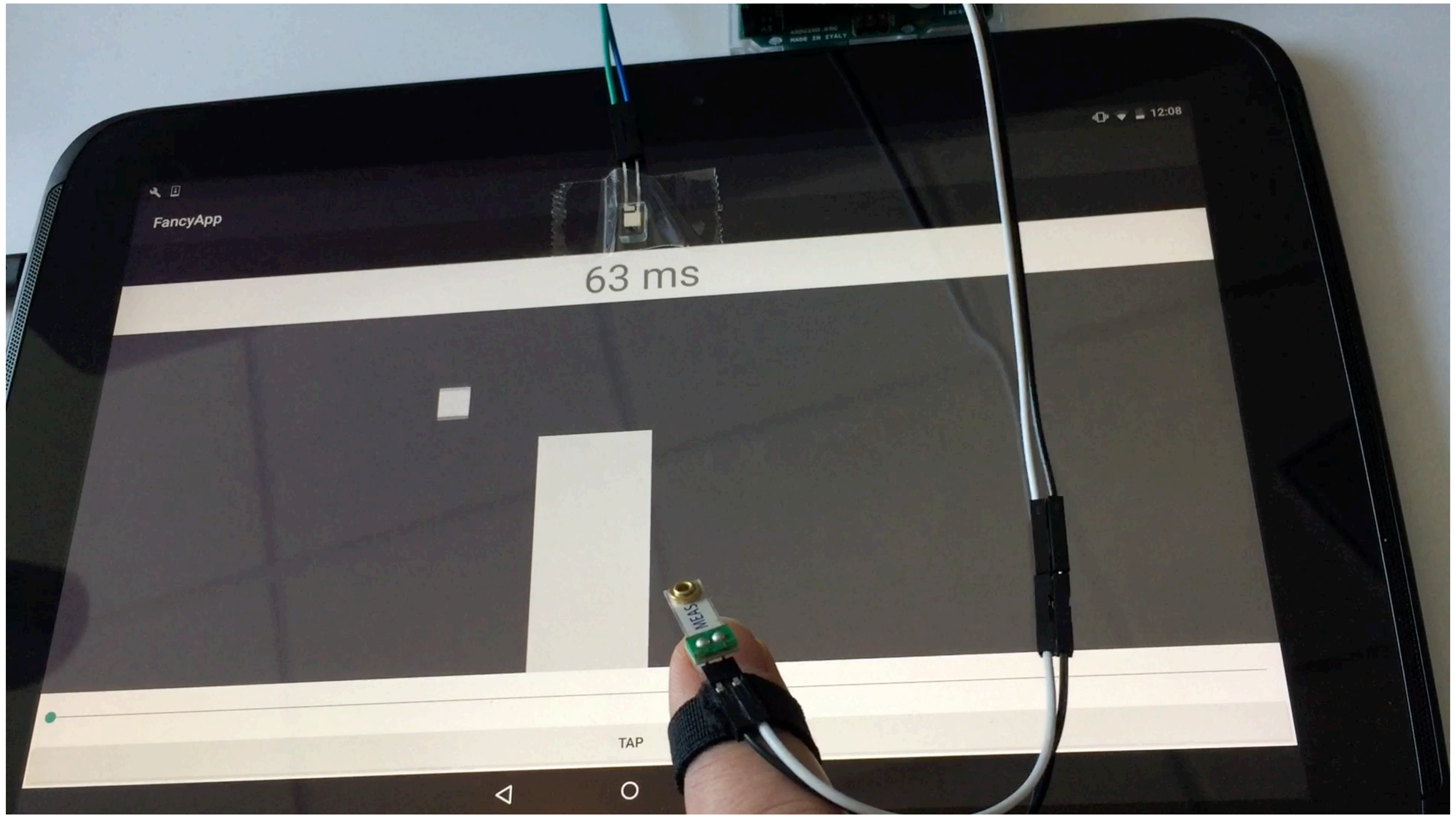
[Casiez et al. 2015]

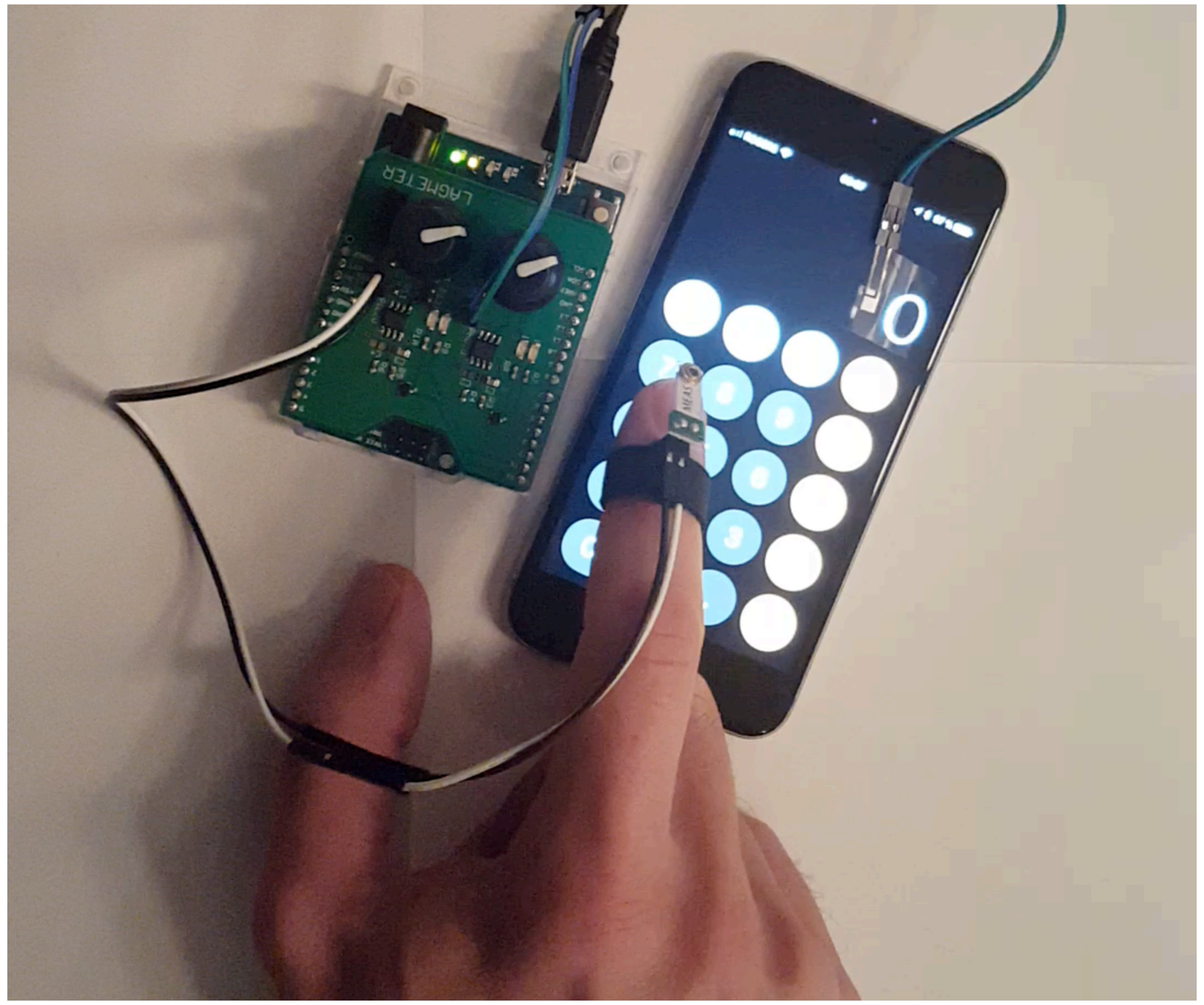




[Casiez et al. 2017]


VCC
6k8
LM311D
100n
1k
THRPHOTO
PHOTO
Q1
SCRINPUT
SIGPHOTO
100n
1k
1k


FancyApp
63 ms
TAP


LAGMETER


Logitech
G9x

	iPhone 6	iPad Air 2	Nexus 10 - Android 5.1.1		MOTO X2 - Android 6.0		Galaxy S7 Edge - Android 7.0	
	end-to-end	end-to-end	repaint	end-to-end	repaint	end-to-end	repaint	end-to-end
native	53.0 (4.0)	48.3 (5.3)	23.7 (3.6)	76.0 (5.5)	25.5 (2.2)	68.5 (4.7)	14.2 (3.2)	67.3 (5.5)
Qt	52.6 (4.0)	73.3 (6.2)	26.5 (3.5)	116.4 (5.6)	15.8 (2.6)	70.8 (6.0)	14.2 (3.0)	75.1 (5.3)
JavaFX	70.4 (7.1)	66.2 (8.3)	29.3 (3.6)	89.6 (7.3)	20.7 (2.3)	69.8 (6.5)	19.6 (3.1)	78.2 (7.0)
Unity3D	66.1 (9.5)	65.8 (9.0)	45.9 (5.2)	116.3 (5.3)	37.2 (4.6)	108.2 (4.6)	33.9 (5.4)	108.3 (5.6)
HTML5 / Canvas	100.8 (6.3)	77.0 (5.2)	28.0 (3.4)	275.9 (17.1)	16.1 (2.5)	61.8 (5.5)	13.6 (3.6)	74.5 (6.2)
HTML5 / CSS	82.5 (4.8)	83.3 (7.0)	28.2 (3.4)	80.3 (5.4)	26.6 (2.4)	71.0 (5.1)	14.2 (3.4)	76.4 (8.6)
HTML5 / WebGL	67.4 (5.0)	64.2 (5.1)	25.8 (3.3)	78.7 (5.6)	16.6 (2.7)	62.6 (5.7)	16.2 (2.7)	76.7 (6.1)

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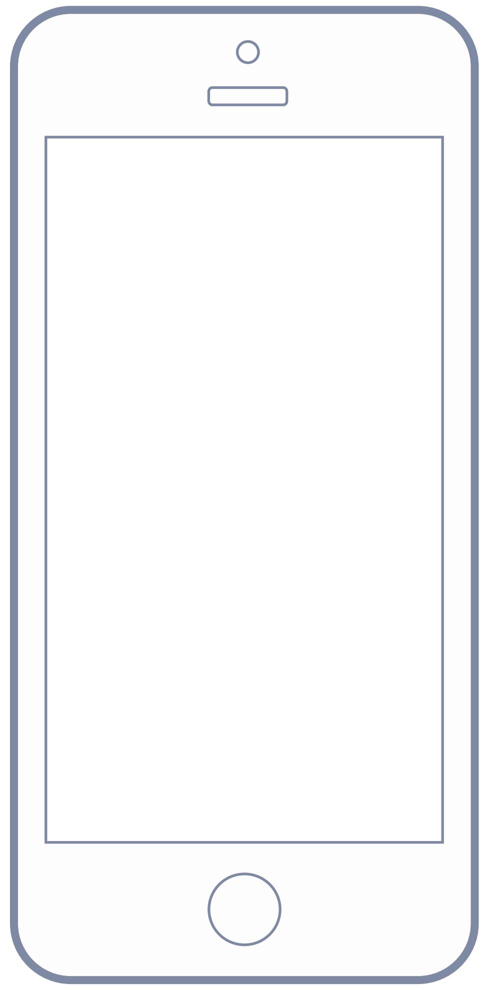
LDAT

Measuring end-to-end system latency traditionally requires recording the input and display using a high-speed camera and then counting the individual frames. This is both expensive and tedious.

To simplify the process of measuring system latency, NVIDIA has created an intuitive and powerful hardware latency measurement tool called LDAT (Latency Display Analysis Tool). LDAT is a discrete hardware analyzer that uses a luminance sensor to quickly and accurately measure the motion-to-photon (click-to-muzzle flash) latency in a game or application. LDAT is cross platform and works with GPUs from all vendors.

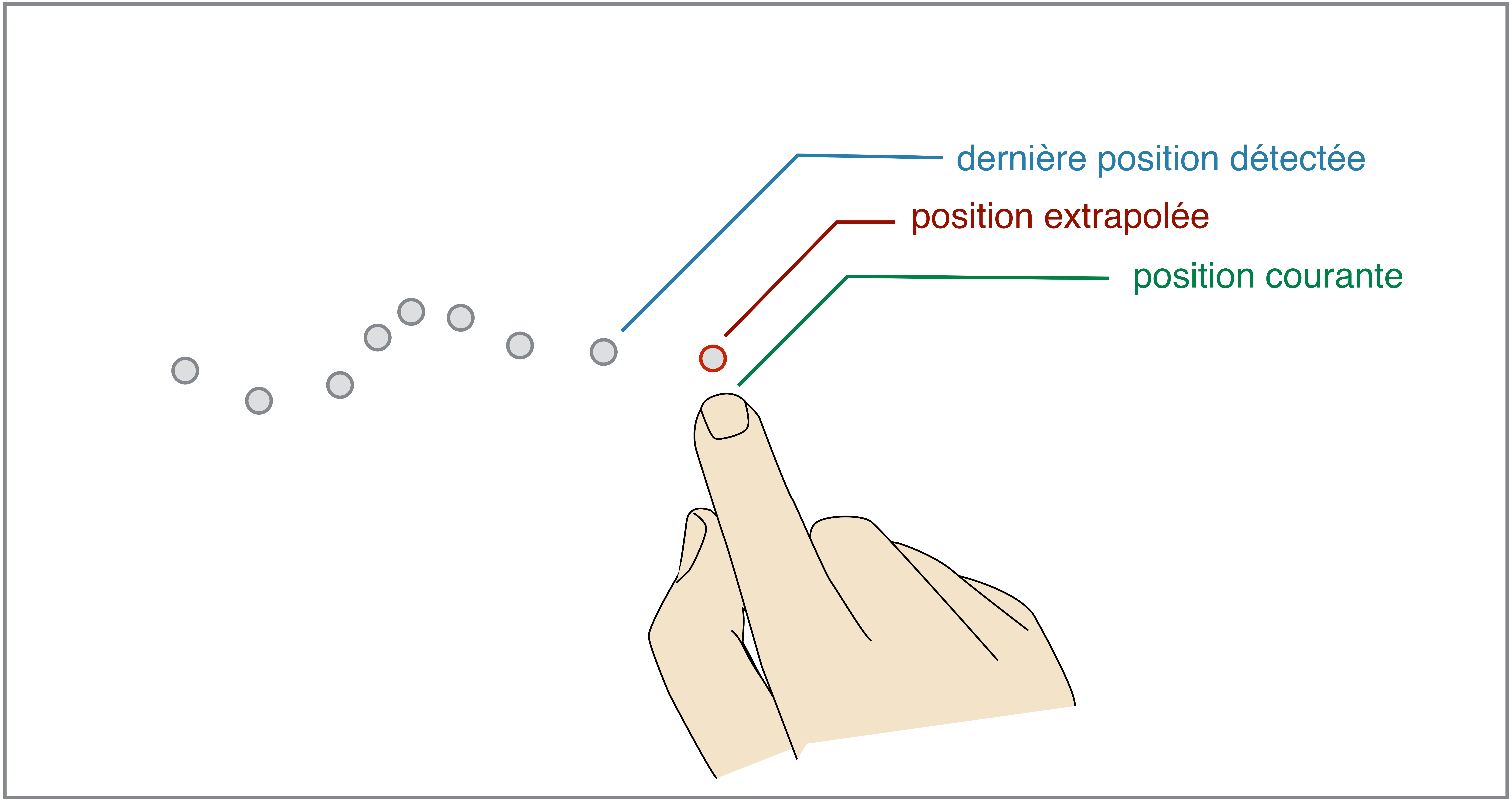
LDAT adds a totally new dimension to measuring and tuning gaming performance, and can answer questions like: "How does resolution or certain in-game settings and effects impact overall end-to-end latency?", or, "How can I tune settings to reduce latency and still maintain great image quality?", or, "How does latency compare among different games I play, and which ones need more latency tuning than others?". Capturing such data was complex and very time consuming in the past—if possible at all. LDAT makes this data available easily and quickly.

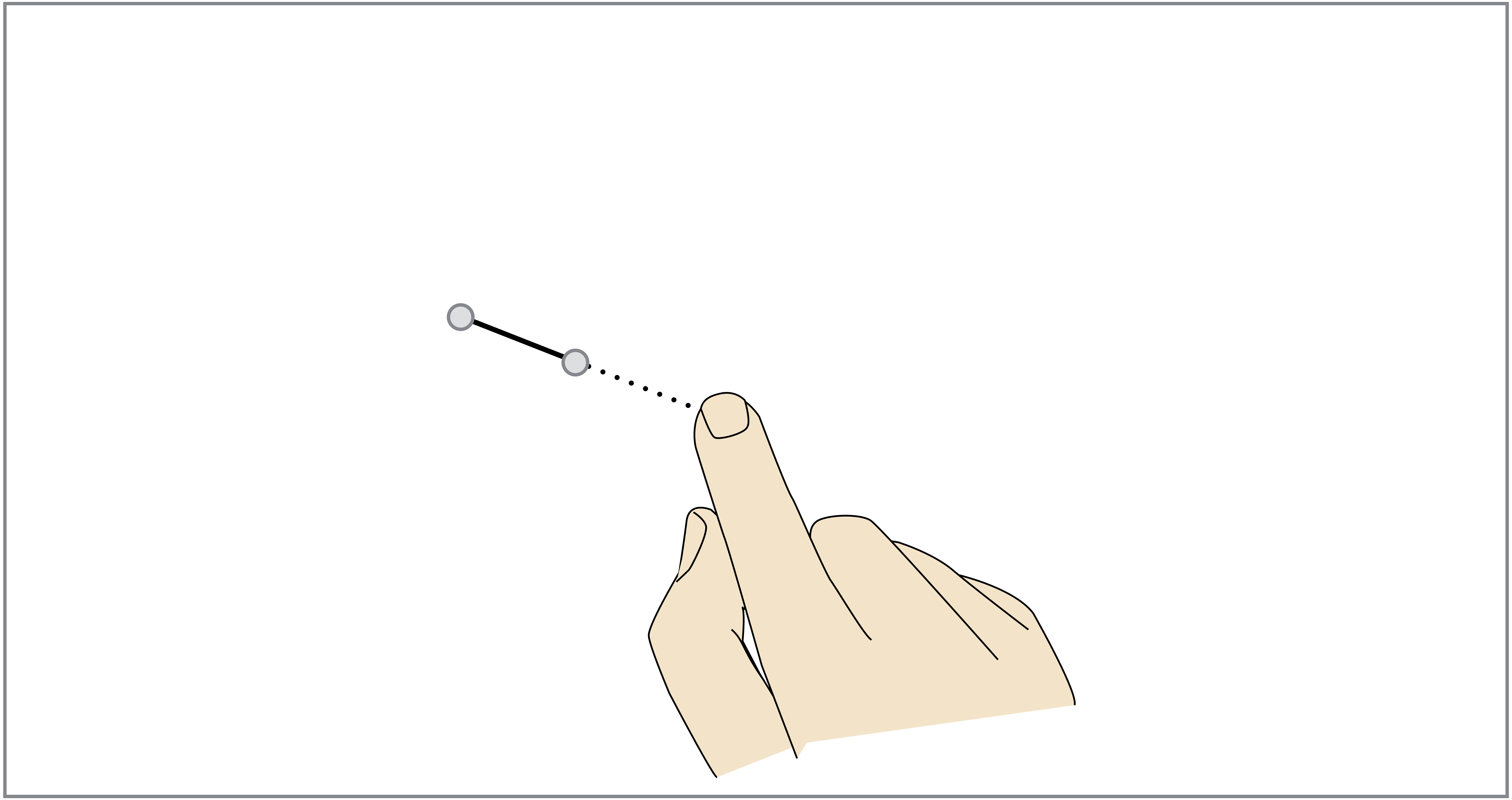
https://www.nvidia.com/en-us/geforce/news/nvidia-reviewer-toolkit/

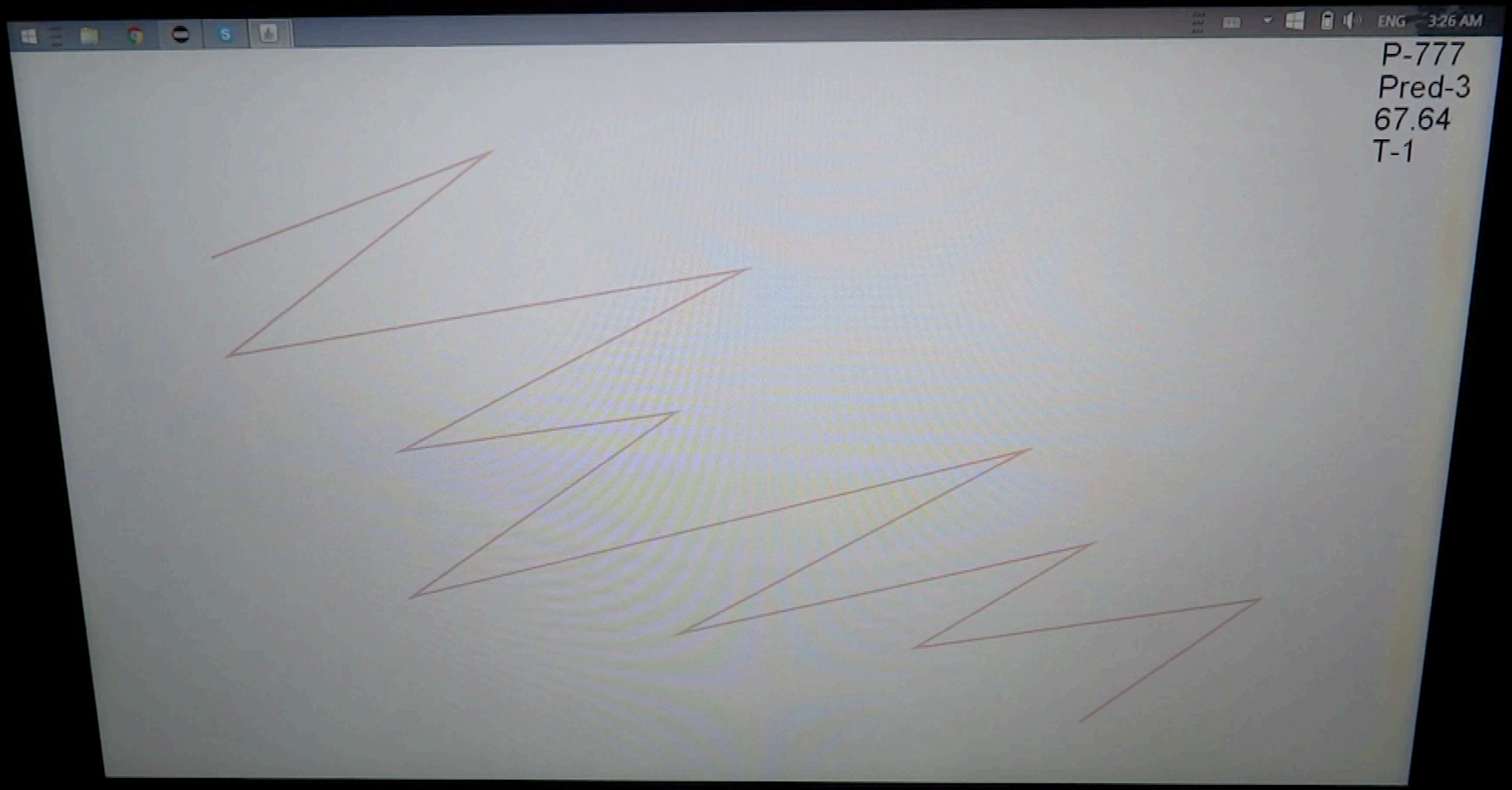


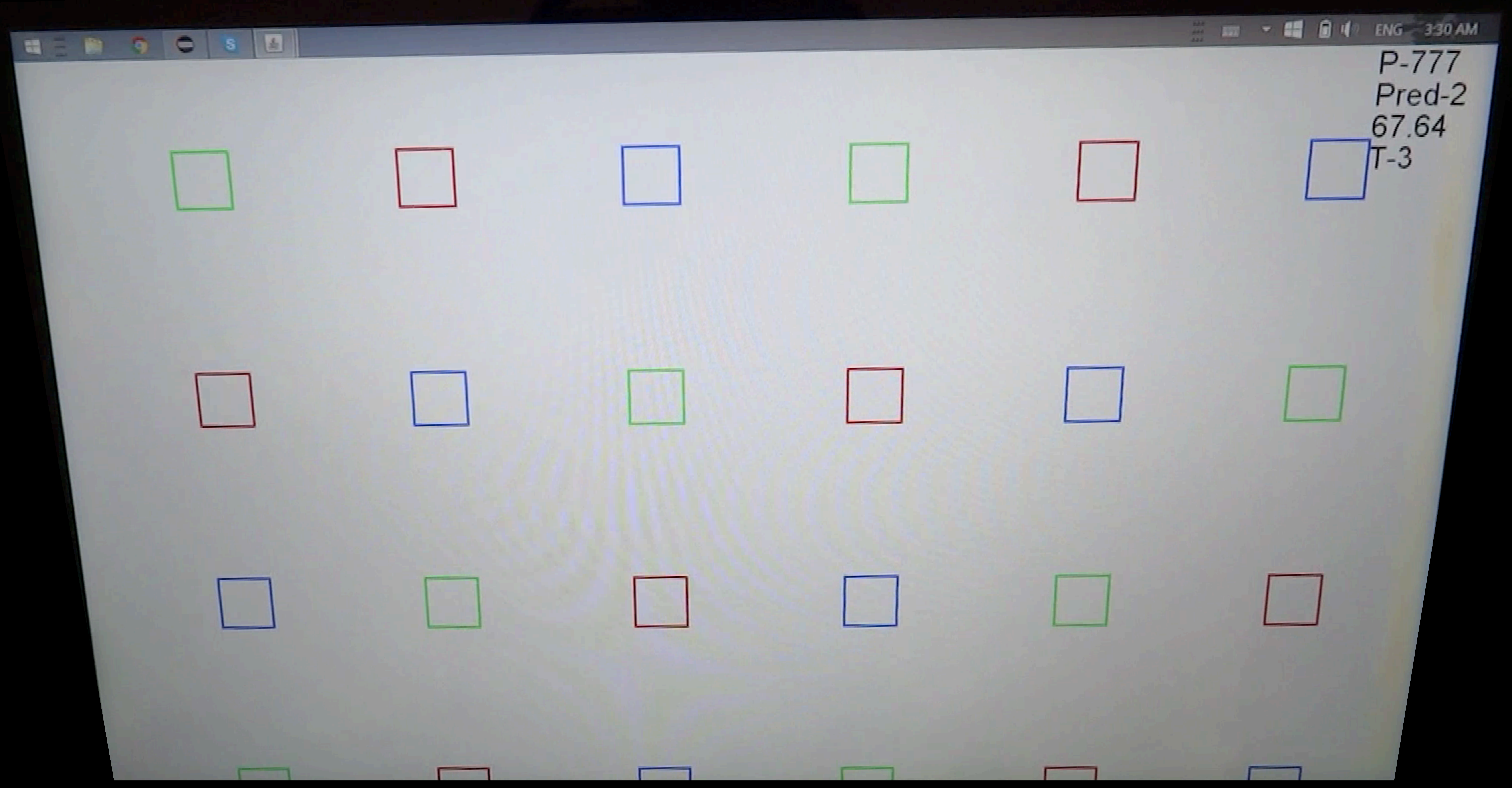
Entre 50 et 200 ms

Entre 20 et 125 ms


dernière position détectée
position extrapolée
position courante

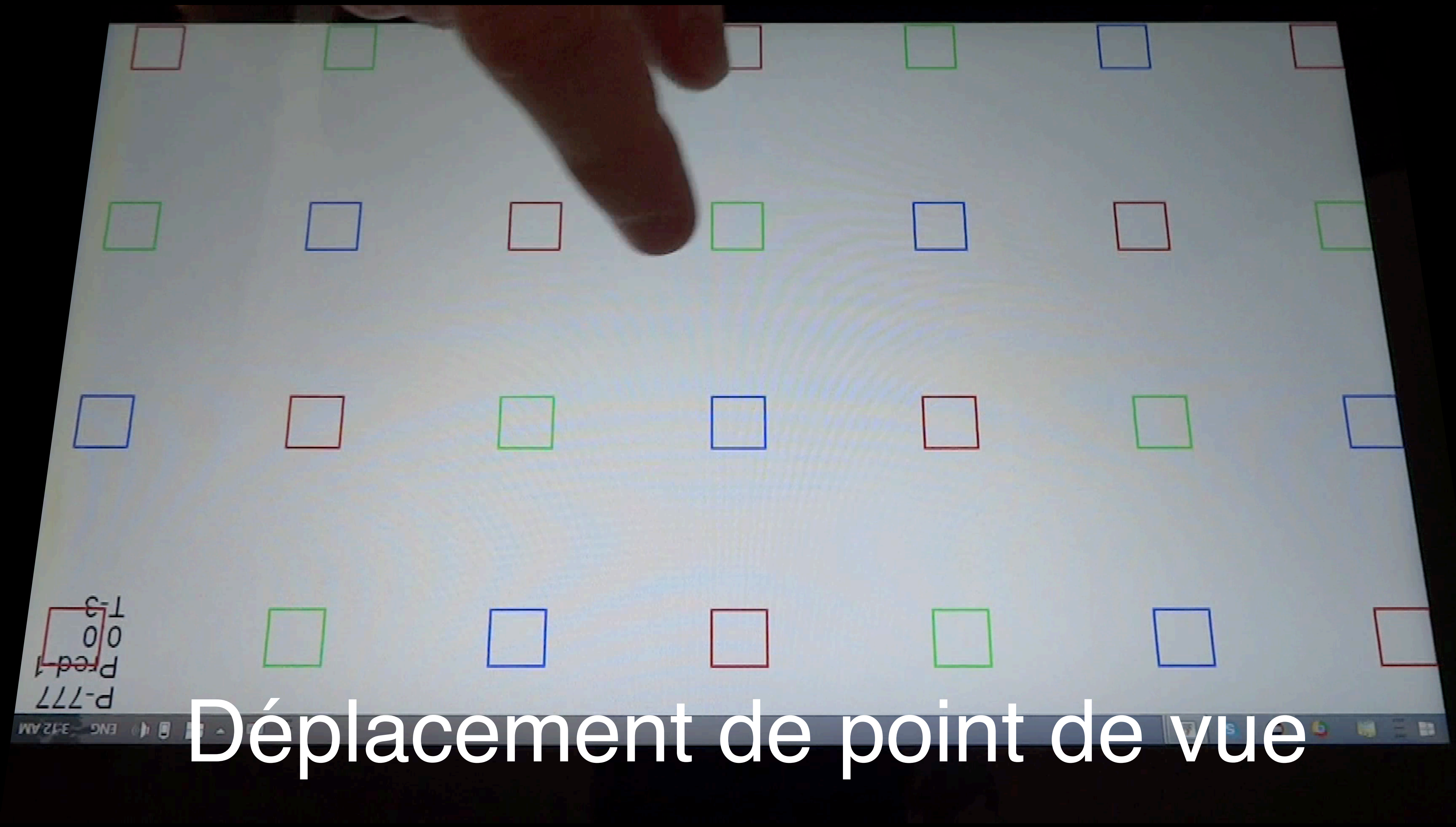



ENG 3:26 AM
P-777
Pred-3
67.64
T-1


ENG 3:30 AM
P-777
Pred-2
67.64
T-3

Dessin

Déplacement d’objet



Déplacement de point de vue

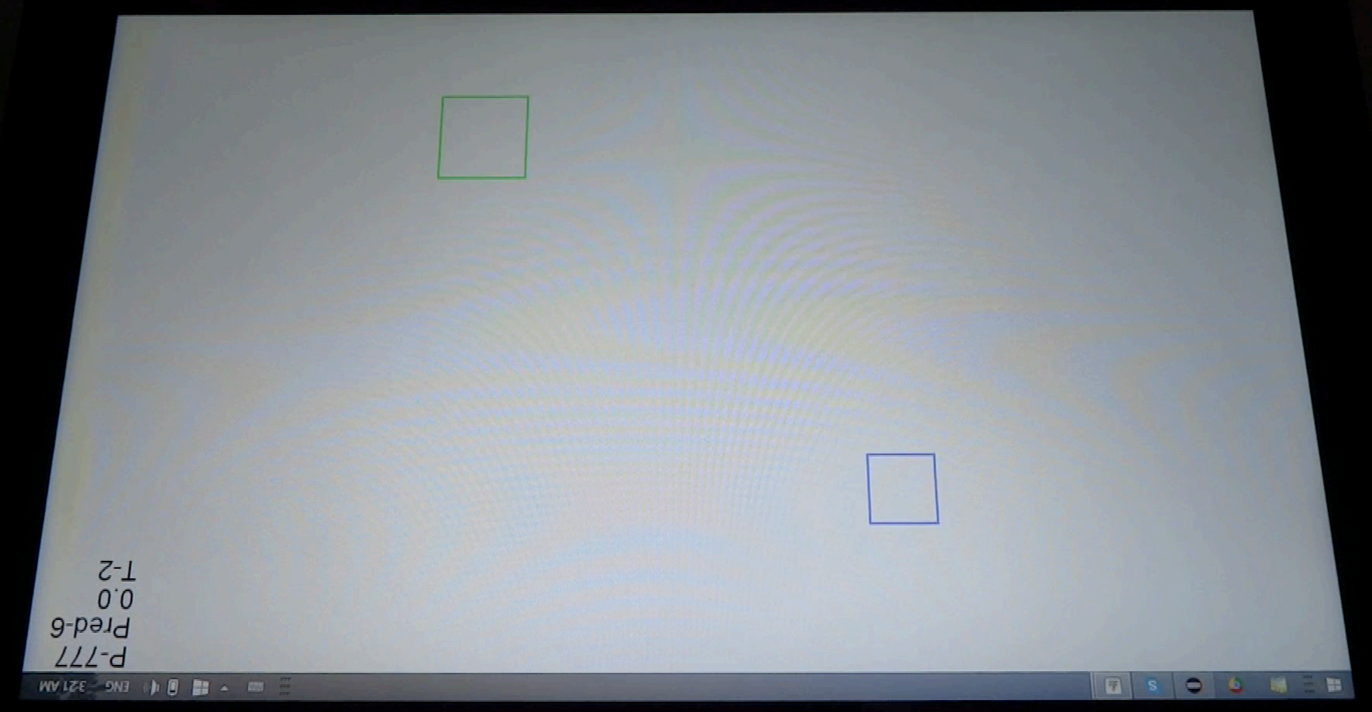
Analyse thématique

30 mots-clés, 4 catégories :

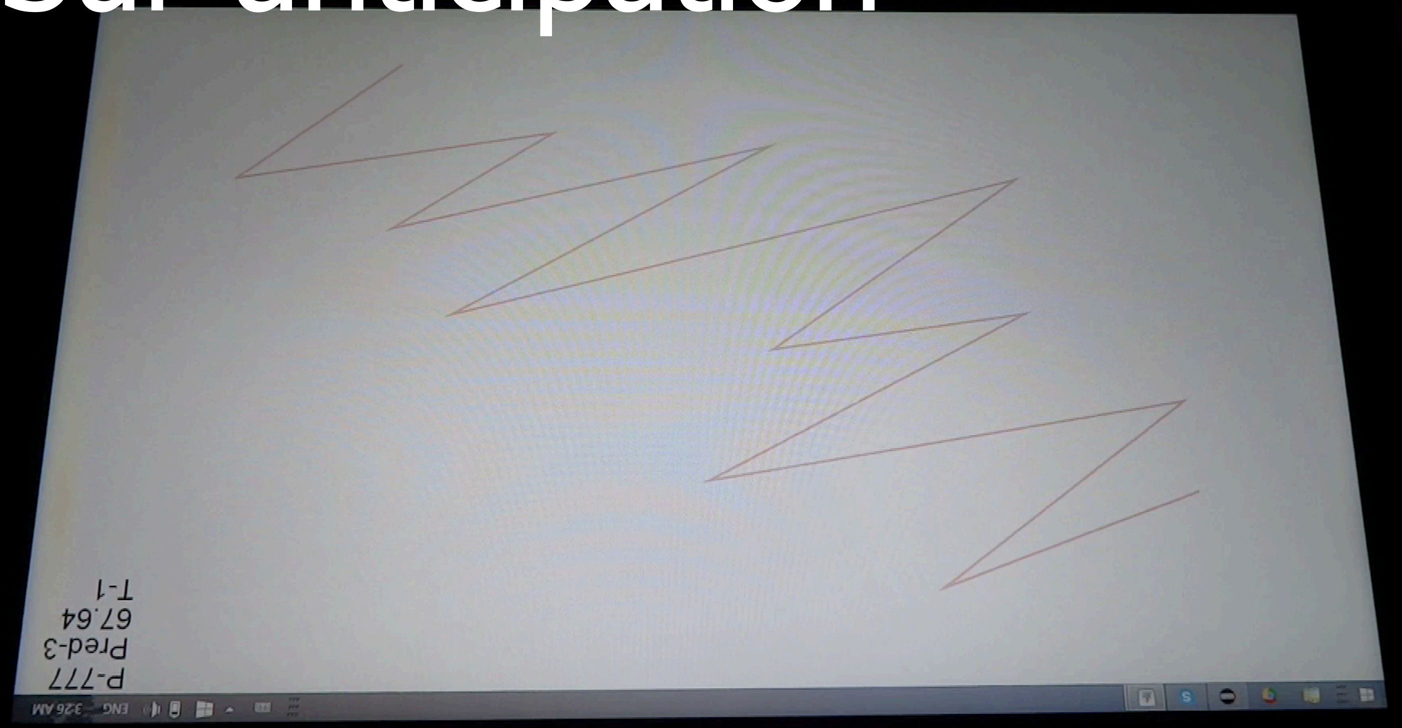
- Effets indésirables (8 mots-clés)
- Conséquences (8 mots-clés)
- Contexte (13 mots-clés)
- Non-négatif (1 mots-clé)

“trop rapide"
“ne va pas dans la bonne direction"
“tremble"

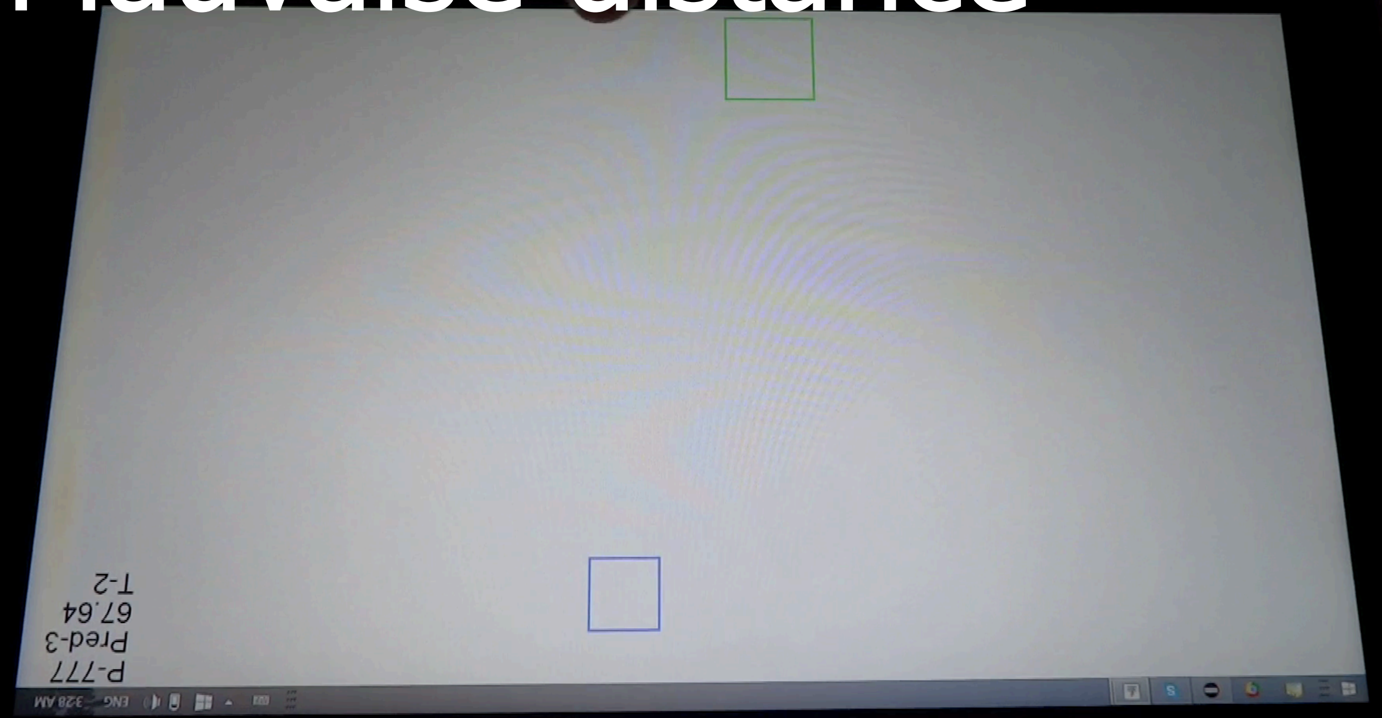
Retard



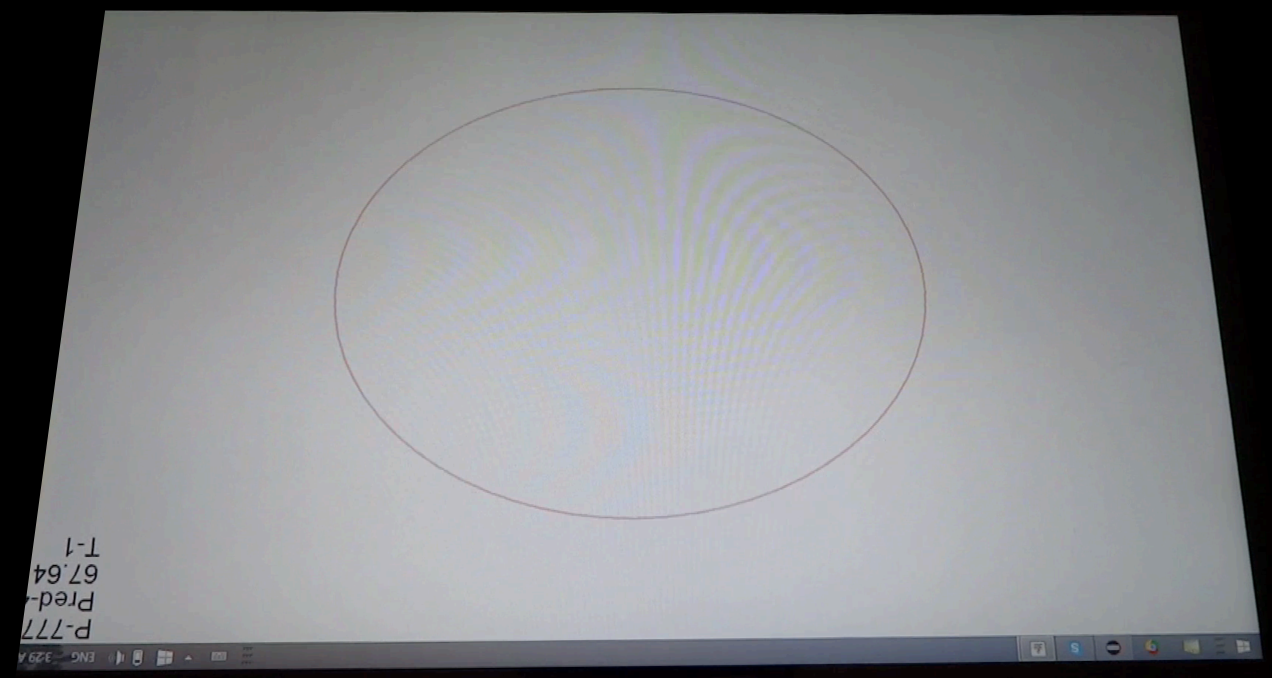
Sur-anticipation



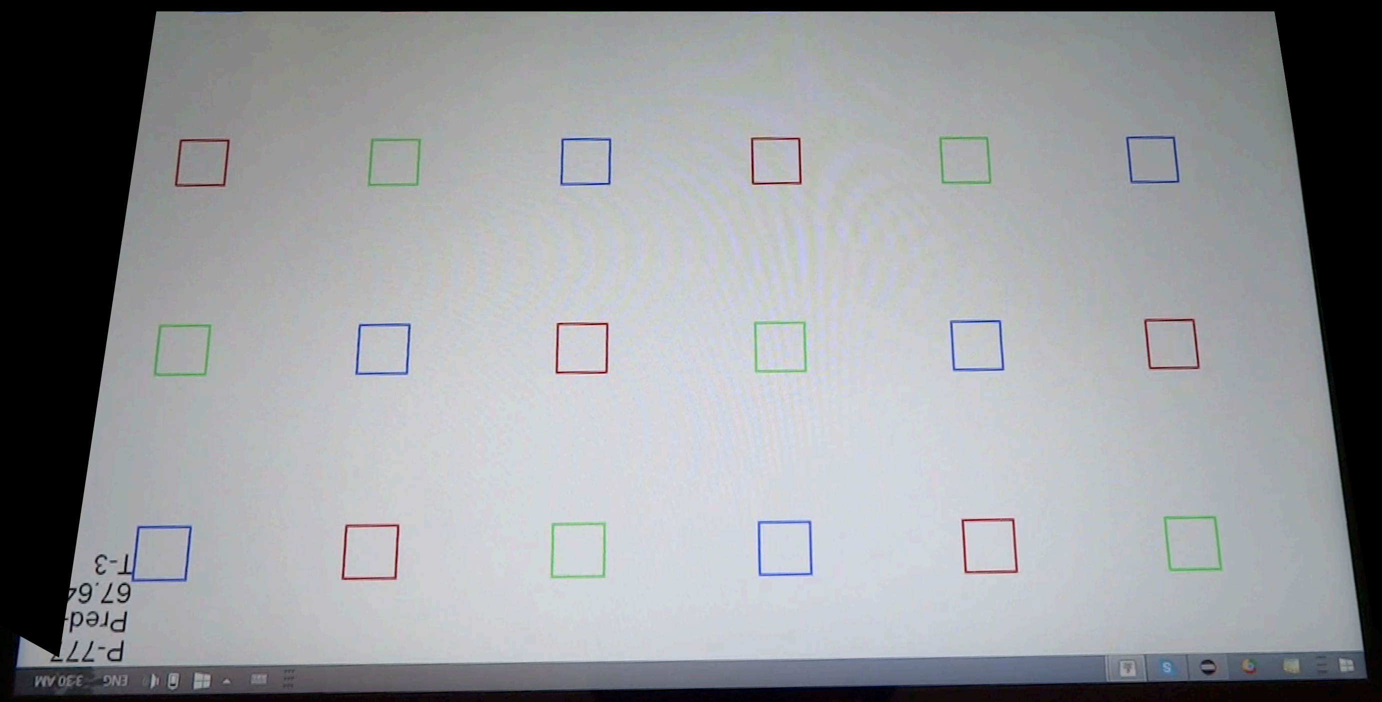
Mauvaise distance



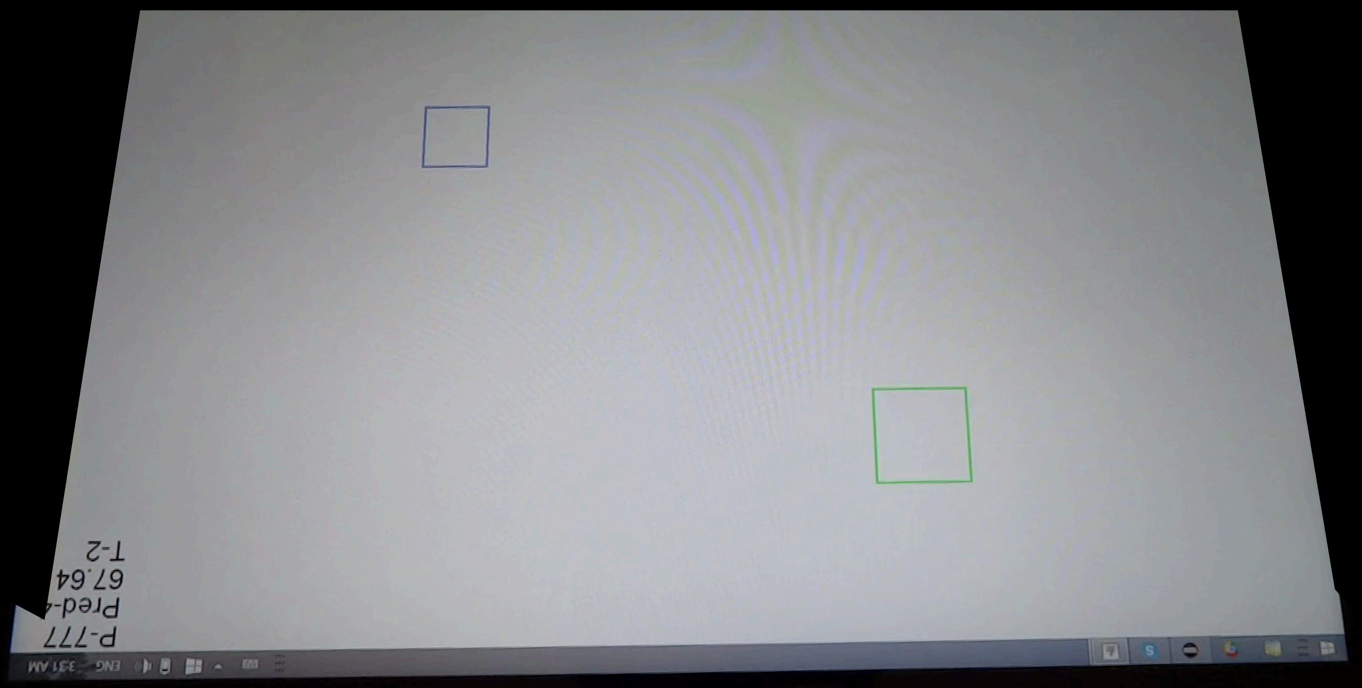
Mauvaise orientation



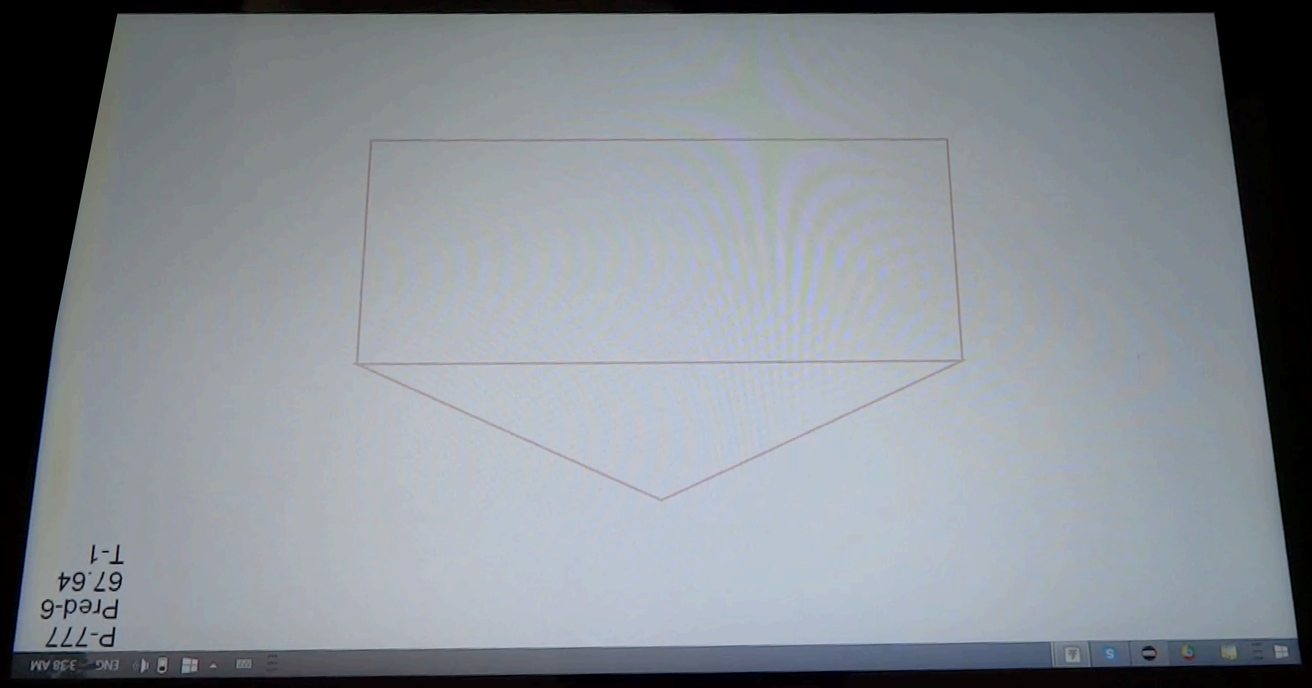
Tremblements



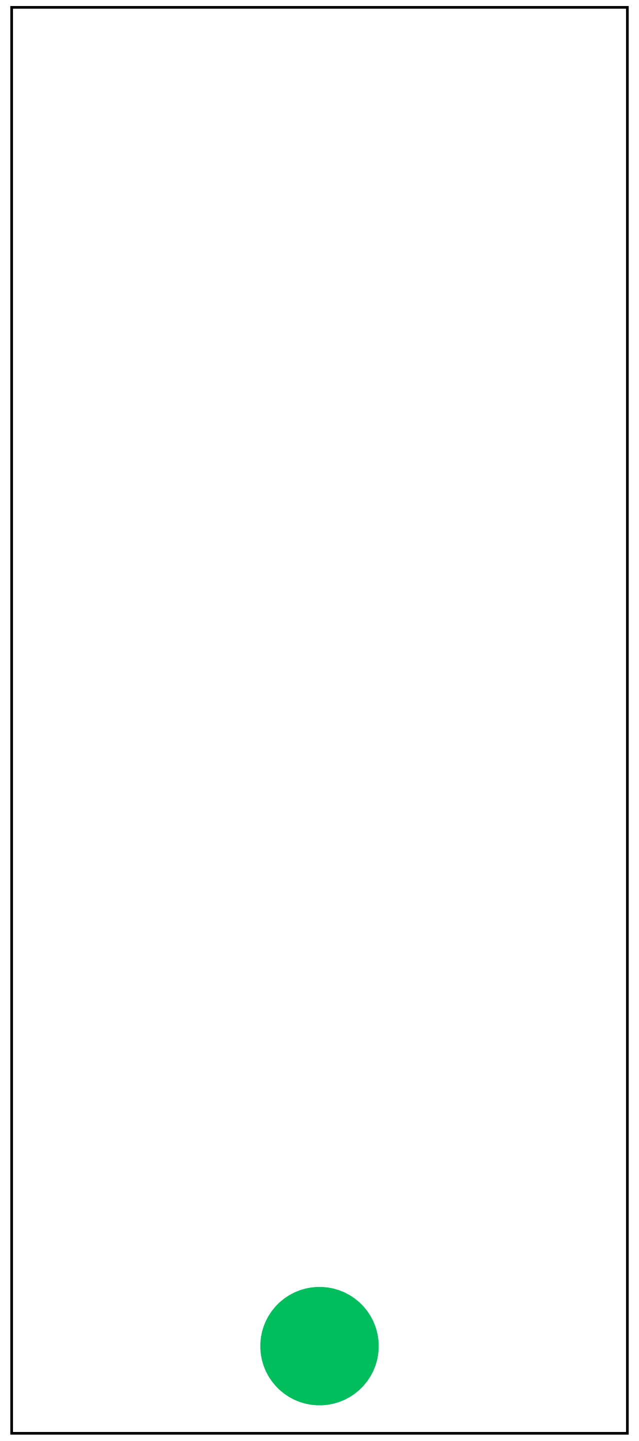
Sauts



Effet ressort

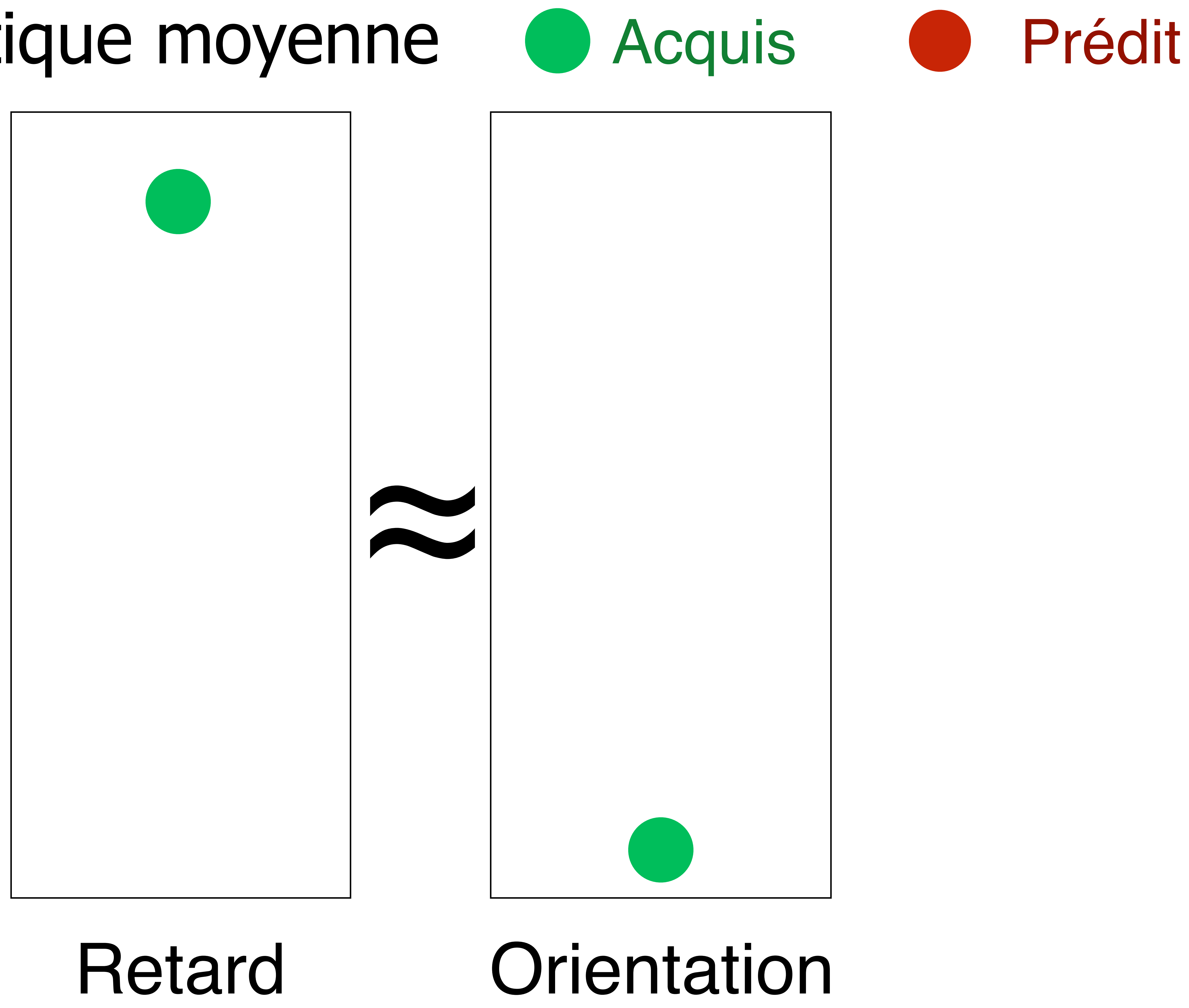


Erreur quadratique moyenne Acquis Prédit

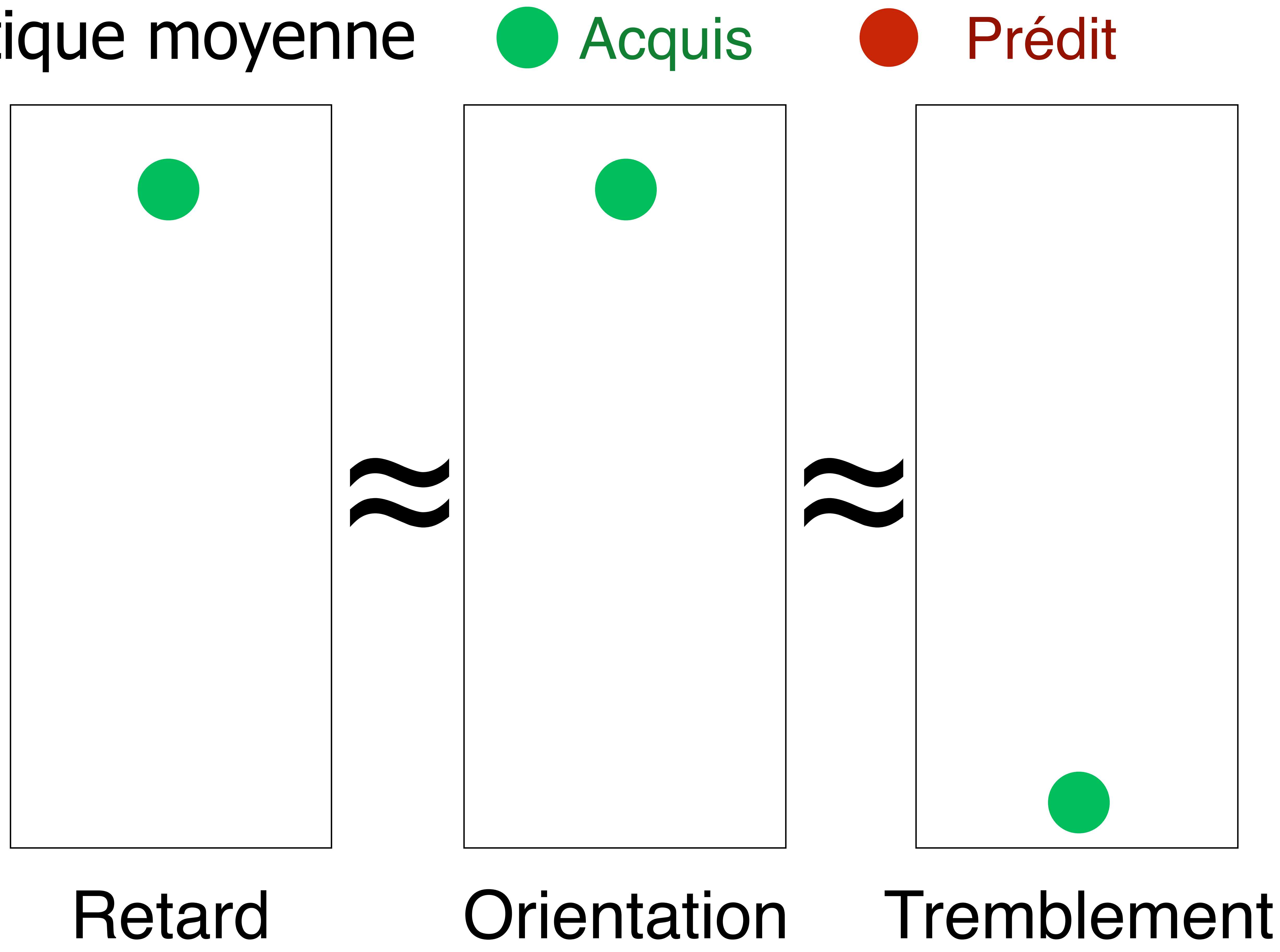


Retard

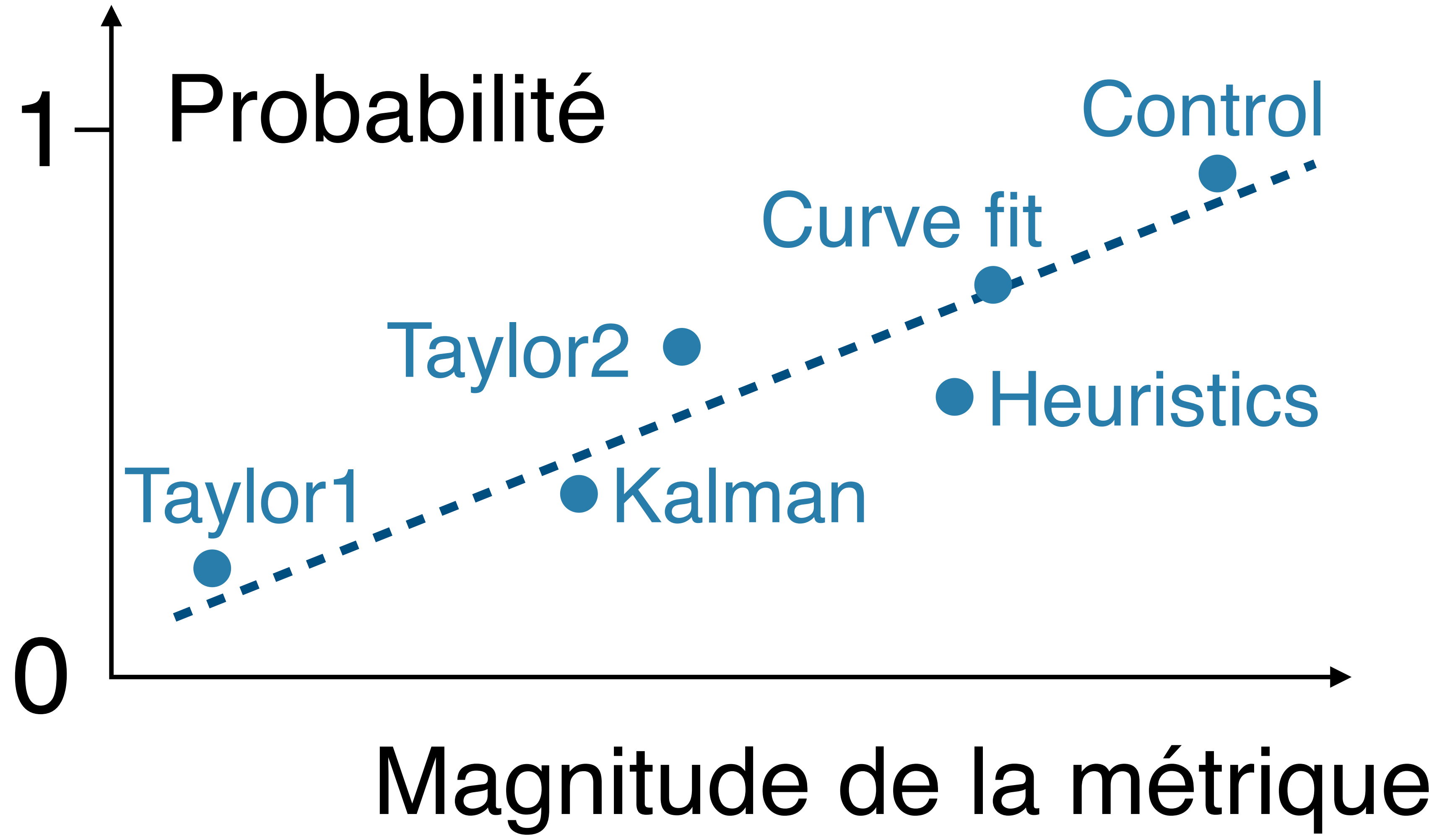
Erreur quadratique moyenne



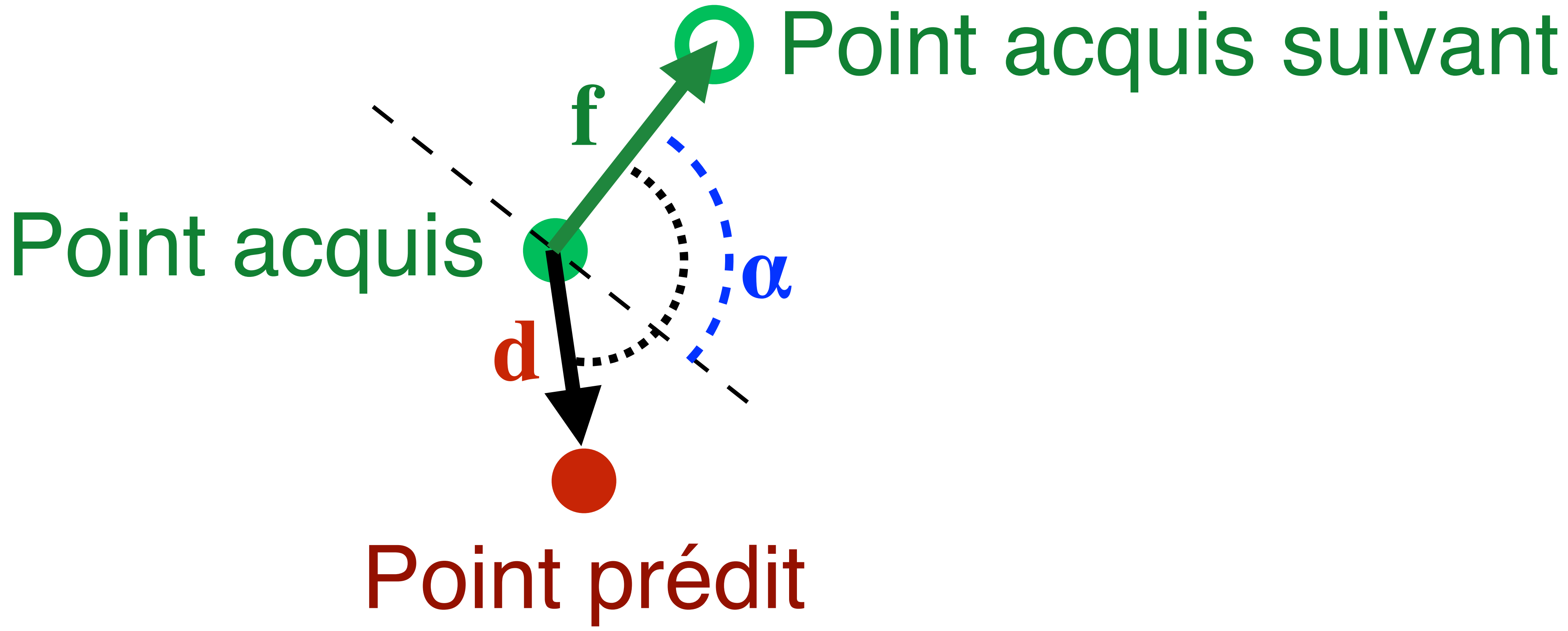
Erreur quadratique moyenne



$$\frac{\text{\#mentions d'un effet indésirable (pour une technique de compensation)}}{\text{\#participants} \times \text{\#tâches}}$$



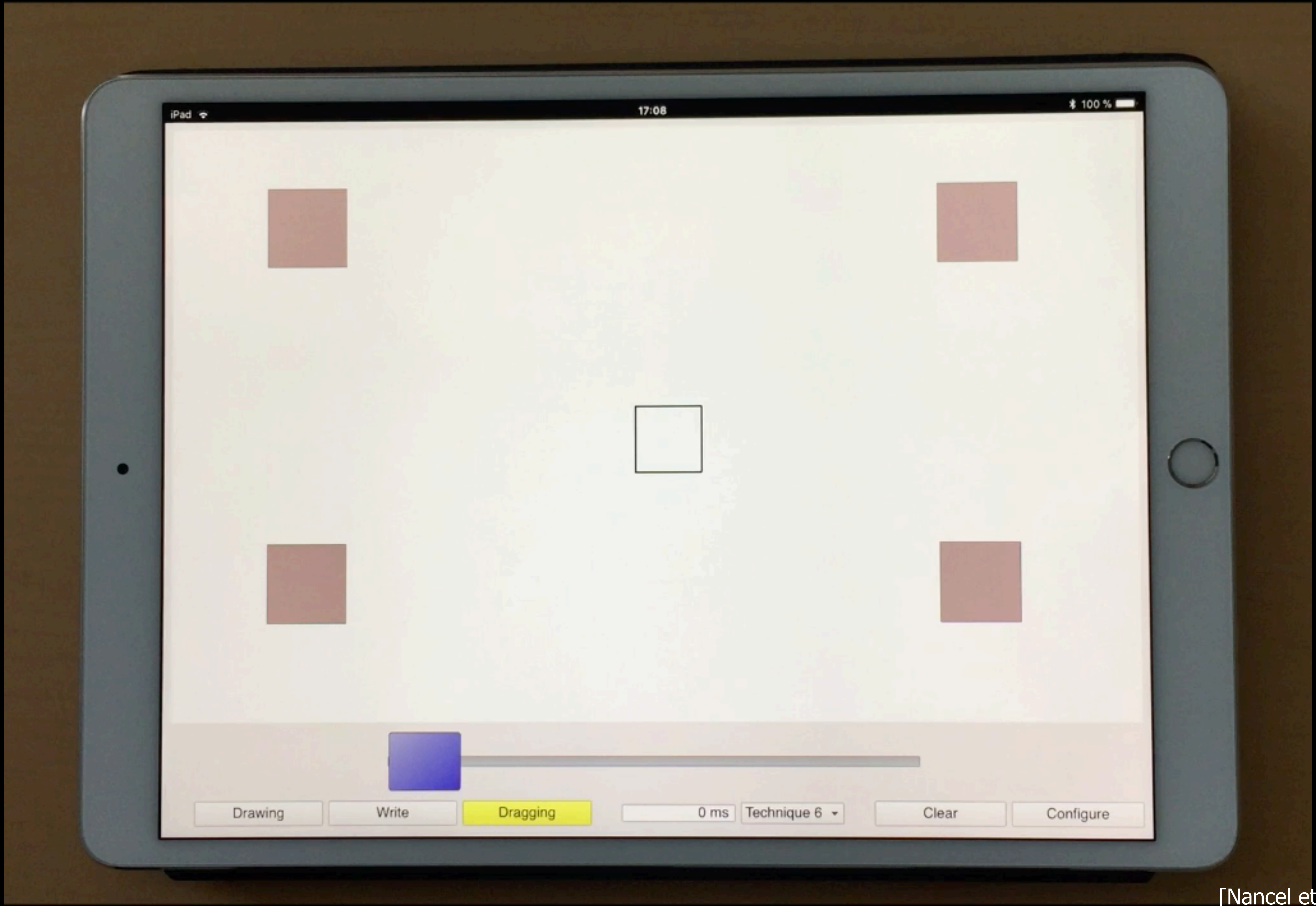
$$L(\alpha) = \frac{1}{m} \sum_{i=1}^{n-1} ||\mathbf{d}||, \text{ if } |\text{angle}(\mathbf{f}, \mathbf{d})| > \alpha$$



[Nancel et al. 2016]

	"*lateness*"			"*over-anticipate*"			"*wrong distance*"			"*wrong orientation*"			"*jitter*"			"*jumps*"			"*spring effect*"		
	m	b	r^2	m	b	r^2	m	b	r^2	m	b	r^2	m	b	r^2	m	b	r^2	m	b	r^2
RMSE metric	0.3	-10.0	0.81	-0.1	31.4	0.14	-0.1	43.7	0.49	-0.1	22.8	0.35	-0.2	49.6	0.76	-0.2	37.2	0.82	-0.0	21.8	0.22
95^{th} percentile metric	0.1	-12.6	0.74	-0.0	31.4	0.11	-0.1	45.3	0.45	-0.0	24.4	0.37	-0.1	51.0	0.66	-0.1	39.0	0.75	-0.0	22.7	0.24
Lateness metric	**0.2**	**-5.9**	**0.90**	-0.1	34.4	0.32	-0.2	43.6	0.70	-0.1	22.6	0.49	-0.2	44.3	0.74	-0.1	33.6	0.82	-0.0	21.3	0.26
Over-anticipation metric	-0.6	43.5	0.65	**0.6**	**1.0**	**0.89**	**0.5**	**8.8**	**0.78**	0.2	5.4	0.44	0.4	7.1	0.37	0.3	7.0	0.34	0.1	13.5	0.11
Wrong orientation metric	-2.3	79.1	0.86	0.9	-2.4	0.22	1.4	-9.4	0.61	**1.0**	**-10.6**	**0.76**	1.7	-20.6	0.59	1.4	-17.3	0.78	0.1	12.9	0.03
Jitter metric	-2.2	72.4	0.85	0.9	-0.7	0.24	1.5	-7.7	0.71	0.7	-2.5	0.42	**2.0**	**-22.8**	**0.84**	1.5	-17.2	0.99	0.2	11.2	0.09
Jump metric	-2.0	59.5	0.76	0.7	8.4	0.13	1.3	1.8	0.59	0.6	1.9	0.35	1.9	-12.9	0.82	**1.5**	**-10.0**	**1.00**	0.2	13.0	0.06
Spring effect metric	-538.6	25.5	0.01	986.1	16.0	0.03	607.1	22.3	0.01	-35.9	13.1	0.00	7.0	20.8	0.00	-65.0	16.5	0.00	**2006.9**	**7.3**	**0.77**

[Nancel et al. 2016]



[Nancel et al. 2018]

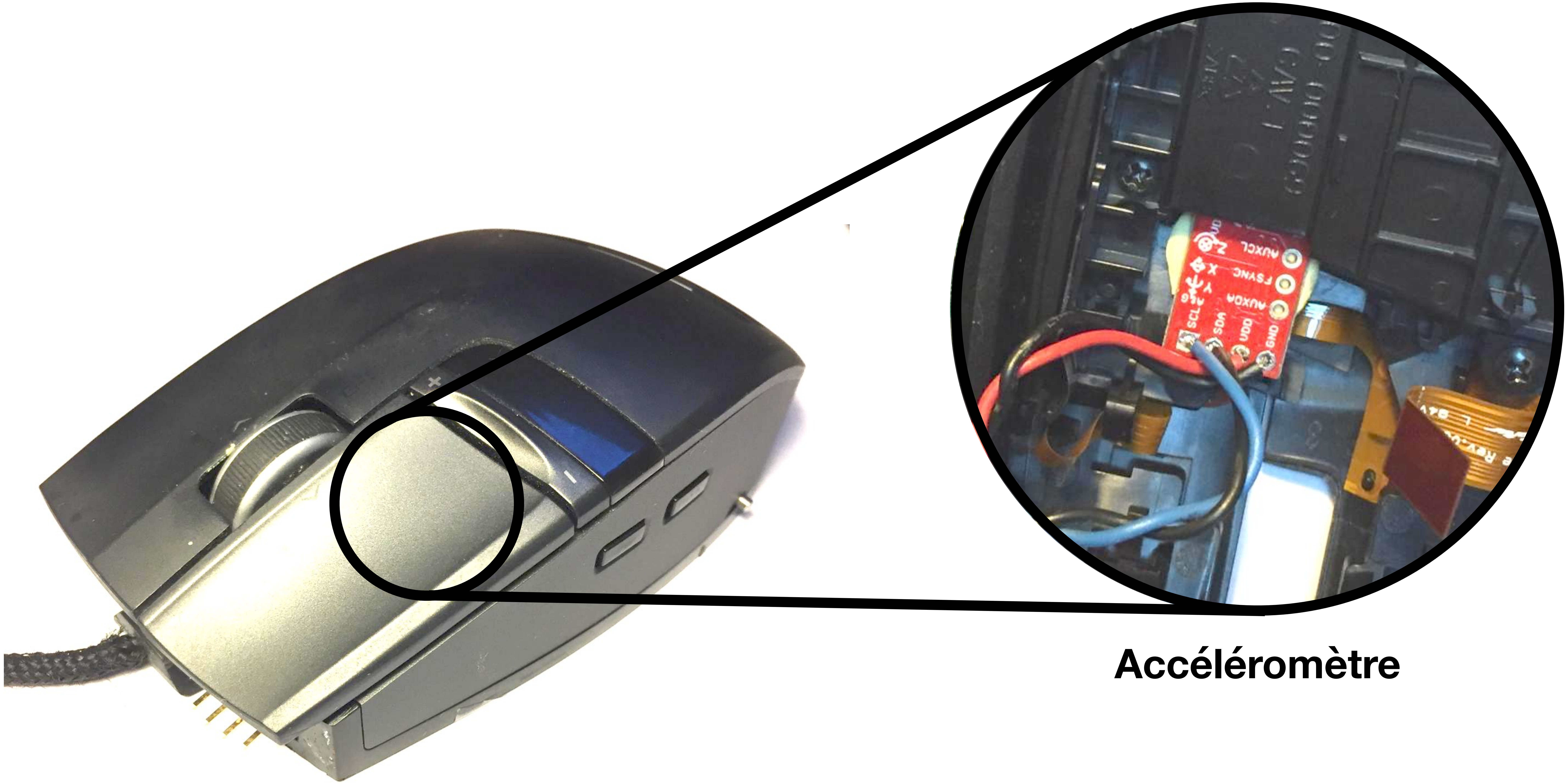
This demo compares a simple linear predictor to the TurboTouch predictor, for different amounts of latency. The red line corresponds to the prediction. The TurboTouch predictor has been configured with parameters that work best with an iPad Pro and that may not be o described in the associated research paper. Please refer to these projects to measure the end-to-end latency of your device.

Predictor Linear TurboTouch **Latency compensated (ms)** 0 16 32 48 64 Test using WebGL Hide instructions

55 fps - prediction computation time: 0 ms

http://ns.inria.fr/loki/TTp/

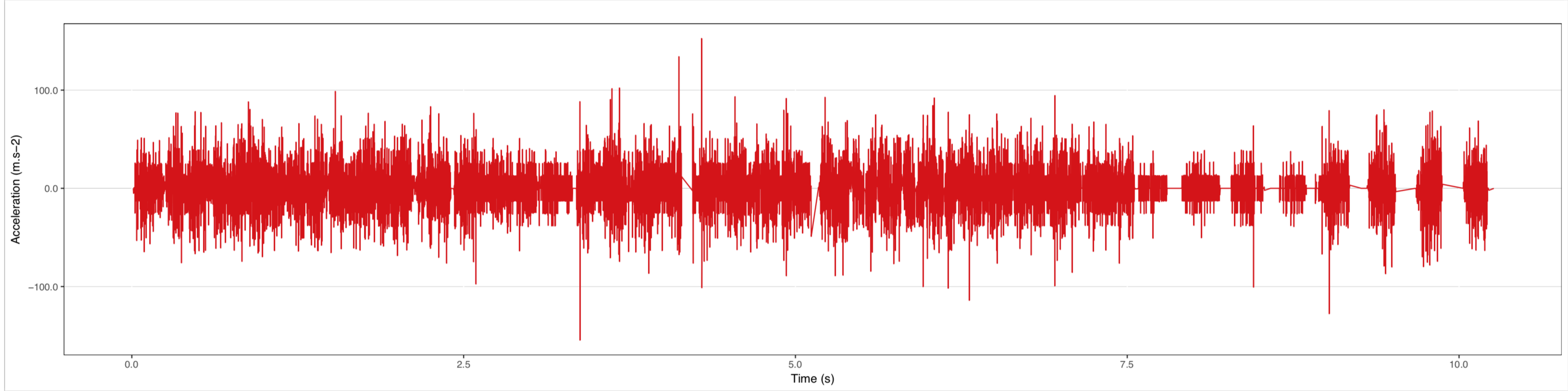
TurboMouse



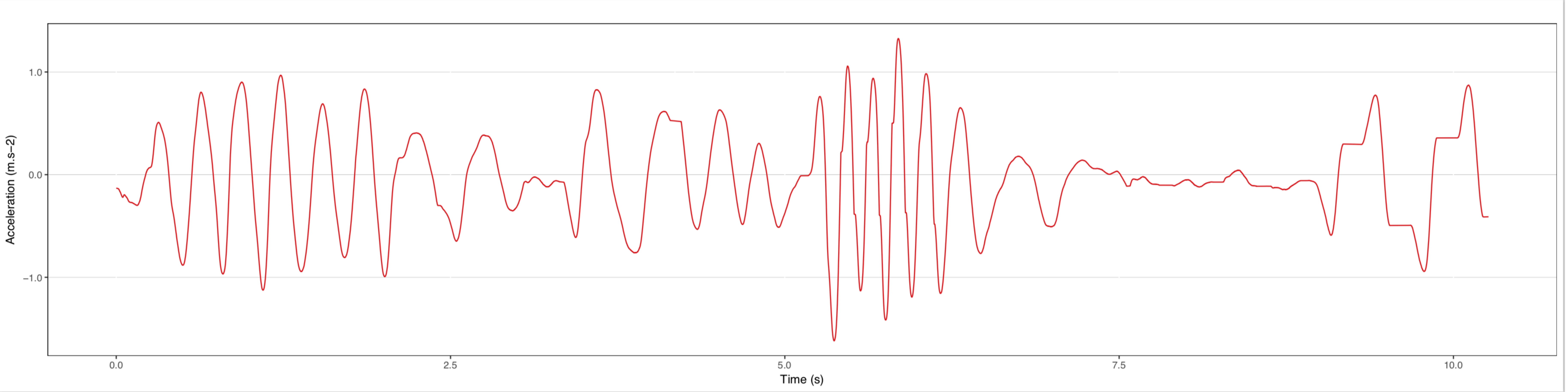
Accéléromètre

[Antoine et al. 2018]

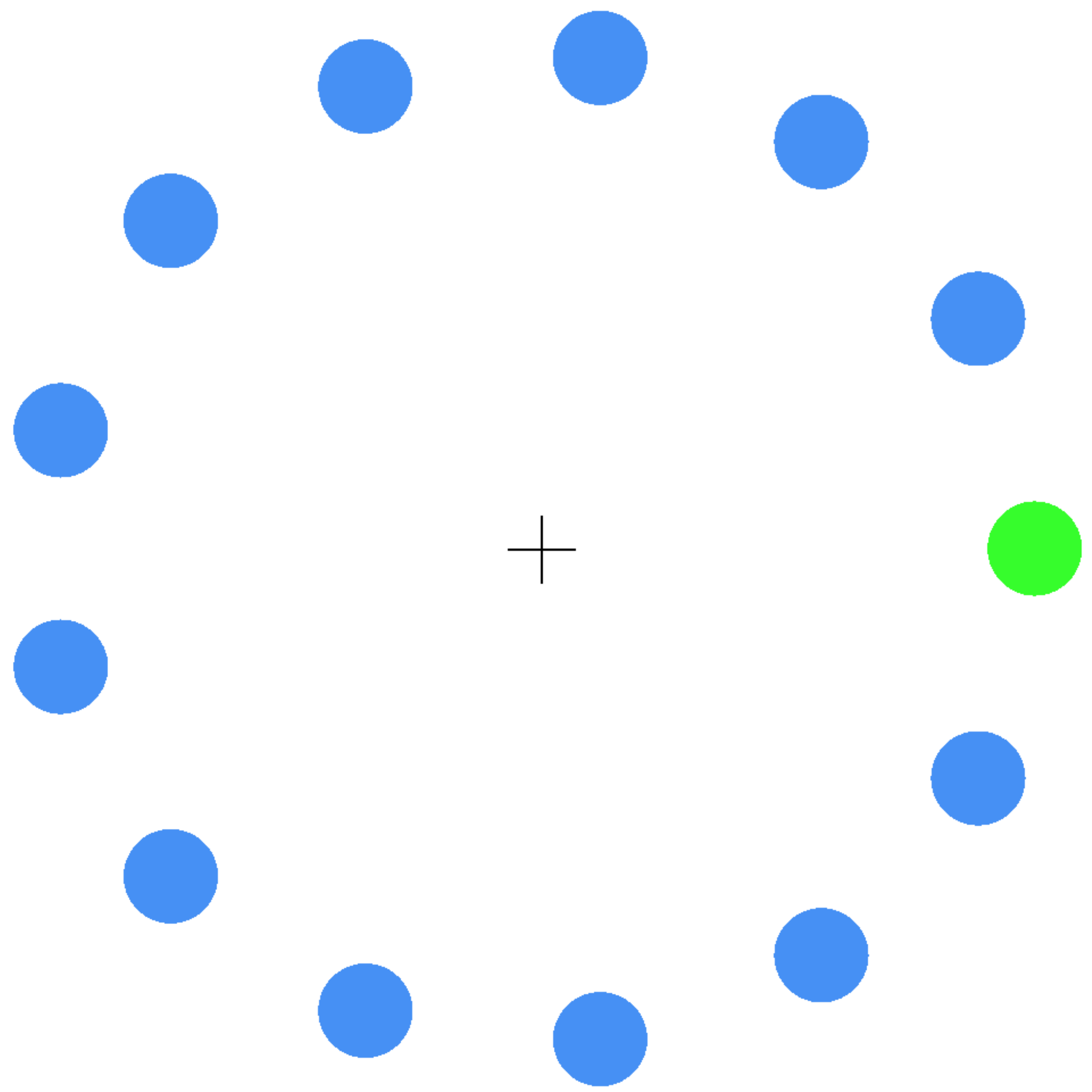
Profils d'accélération

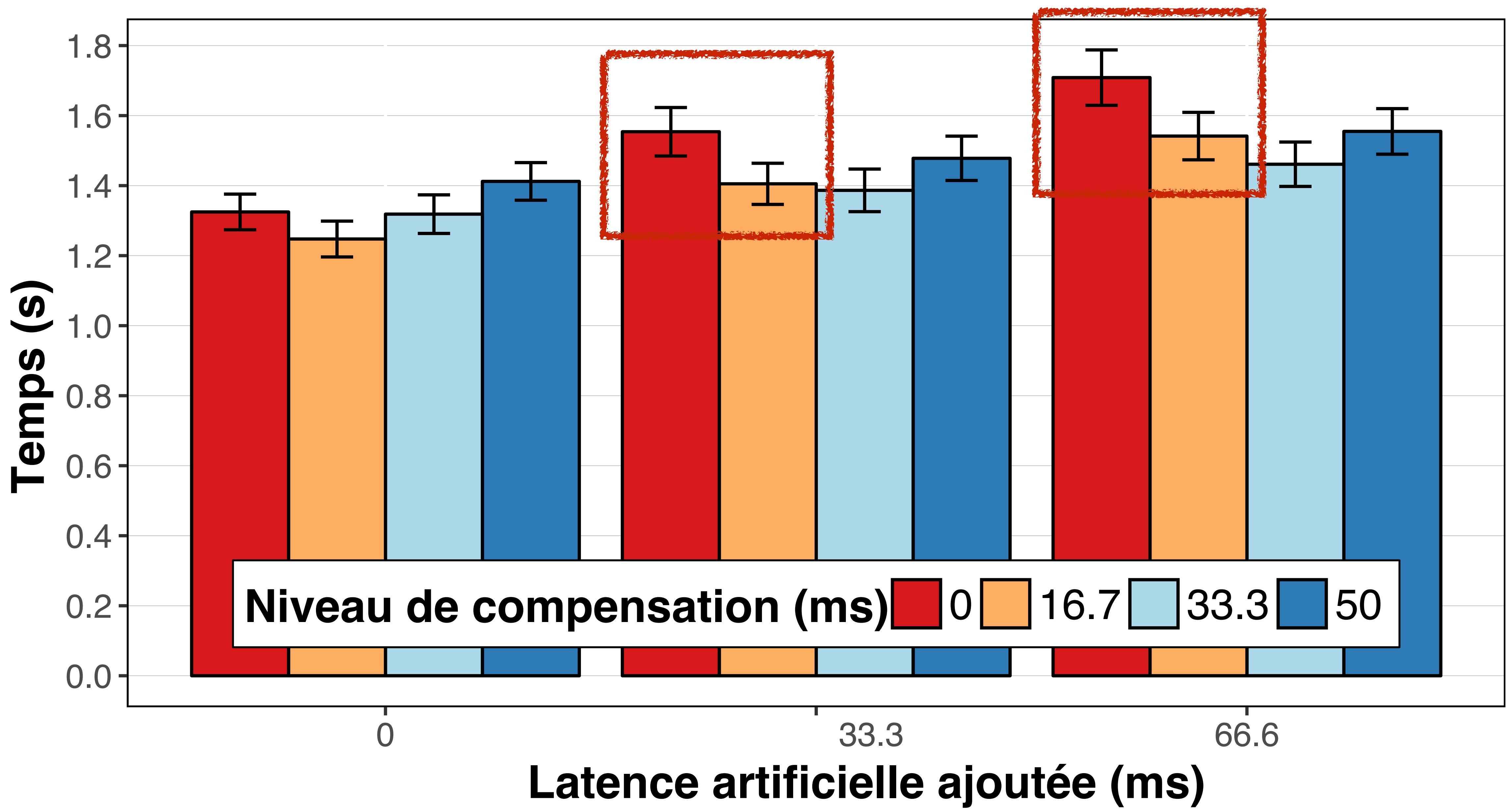


Calculée à partir de dérivées



Mesurée avec un accéléromètre





[Antoine et al. 2018]

Application

Communiquer avec un périphérique

Polling

```
int main()
{
  while (true)
  {
    input();
    update();
    draw();
  }
}
```

Gestion d'événements

```
void onKeyDown(…)
{
  …
}

void onMouseMove(…)
{
  …
}

int main()
{
  while (true)
  {
    update();
    draw();
  }
}
```