2017-2 Human Computer Interaction

29377 characters in 4280 words on 878 lines

Florian Moser

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1 Introduction

1.1 user research method

formative
helps to understand the problem and the users to inform design

build
create new version of the product using the formative methods

evaluative
help to understand how well design works
may inspire new formative methods

1.2 human computer interaction

human
single user, or friends, colleagues

computer
machine running program, distributed, heterogeneous

interaction
user provides input
machine communicates result
user interface main point of interaction between user / machine

1.3 human vs computers

strength of human
signal detection under noise
recognising complex signals (images, voice)
recognising complex configurations (scenes)
concentration to the essential
adaptation to unexpected situations
learning aptitude
memorizing cohesive information
intuition

strengths of computers
superior if problem can be algorithmically formulated
detecting / recognising known signals
fast and reliable reaction to known signals
measuring and counting
storing large amounts of incoherent data
syntactic symbol manipulation
reliable, fatigue-free repetition of operations

1.4 components of cognition

perception (using sensory systems)
Sight (visual)
Hearing (auditory)
Touch (haptic)
Smell (olfactory)
Taste (gustatory)
Balance and acceleration (vestibular)
Body awareness (proprioception, kinesthetic sense)
Temperature (thermo reception)

memory
sensory
short-term STM (controlled cognitive processes)
long-term LTM (declarative, procedural knowledge)

action (using motor systems)
Arms, hands, fingers
Head, face, eyes
Vocal system
Legs, feet, toes
Jaw, tongue

attention flow
stimulus
sensory organs (eye, ear, ...)
sensory register (visual, auditory, ..., may activates the motor system)
symbol recognition (uses LTM and STM)
LTM and STM may activate the motor system

anatomy eye
light travels through cornea (skin around eye)
crystalline lens make image sharp
iris controls amount of light which enters the eye
retina contains rods and cones
rods see light (scotopic vision) but slow reaction
cones see colour (photopic vision) & fast reaction, S M L types
fovea contains cones and where humans see sharp
optic nerve transports information to visual cortex

acuity of visual field
foveal vision (fine details), about 2degrees of sharp vision
peripheral vision (motion), visual acuity decreases with distances from fovea
horizontal field 60deg nasal, 90deg temporally
vertical field 60deg up, 70deg down

usefulness of visual field
low character density 15deg
high character density 1deg-4deg

eye movements (gaze movements)
saccades (repositioning of fovea, 30ms (10ms-100ms), bad perception)
fixations (dwelling on a point, 230ms (150ms-600ms), 90% of the time)

implications for perception
reading speed fixed (10words/sec)
context dependance of gaze movements

1.5 model human processor (MHP)

abstract understanding of perception, memory, motor system
can be used to estimate execution time, error rates, training effects
practice leads to skills which reduces cognitive effort

1.5.1 three processors with associated memory and runtime

perceptual system for sensors & buffers
cognitive system for working memory content
motor system for movements

1.5.2 total processing time

overall system runtime is sum of all runtimes
240 ms = t_perceptual + t_cognitive + t_motor = 100ms + 70ms + 70ms

1.5.3 perceptual processor

how it works
receives sensor signals and stores them in buffer (one buffer per channel)
perception time about 100ms (50-200ms) t_p

blochs law (for $t < 100ms$)
Response = Intensity $*$ TimeOfExposure
can substitute intensity, duration and maintain constant effect
enforces limits on framerate for animations and videos

1.5.4 cognitive processor

how it works
operates on chunks of information
processing time about 70ms t_c
divided into STM and LTM

STM
as working memory
control of cognitive processes (concious such as reading & multiplying, automatic such as visual searching)
repetition and building of connections stores information in LTM
can process limited by number of chunks, but not complexity

capacity 5-9 chunks for 2 sec, 2-4 for 7 sec

LTM
as remembering memory, build on experience
divided in declarative (facts, past events) and procedural (skills)
capacity practically unlimited, but hard to organize for retrieval

1.5.5 motor processor

how it works
controls and runs motor system such as hands, arms, ...
processing time about 70ms

open loop
70ms
no perceptual control
just motor processor commands
in pen experiment the number of changes in direction

closed loop
250ms
with perceptual control
motor processor corrected after input from perceptual processor

1.6 Fitts Law

predict movement time of rapid aimed movements
measure throughput of movements (reaching for stuff, clicking on icon)
very powerful, widely used, comparable over different experiments

fitts thesis
fixed information-transmission capacity of motor system
most limiting ability is the processing of sensory input
tradeoff between speed & accuracy
ID = # of bits required to specify movement
MT = movement time
IP = ID/MT index of performance

formula
difficulty I_d = log2(2D/W) for W target width and D target distance
movement I_m = 100ms/bit
T_pos = I_m ∗ I_d

implications
doubling distance adds constant to execution time
doubling target width is similar to halving distance

bandwidth factors (performance of use)
bandwidth of muscle group which uses device (human)
precision requirement of task (application)
bandwidth of input device (device)

target acquisition
in intervals
come close fast, then correct
each proceeding is slower & more precise

visual feedback loop (using MHP)
t_p (observe hand position), t_c (plan movements), t_m (move hand)
one feedback cycle is (t_p + t_c + t_m) = t = 300ms
first cycle e∗D moved, second e∗(e∗D), .. for e error, D distance
movement stops when (eˆn)∗D ≤ 0.5W for W width of target
resolve to n, use T = I_m ∗ I_d to calculate I_m

in practice
icons should be activatable at their edges (cause easier to hit)
larger icons which are far away
toolbars which appear directly between cursor
upper-left corner buttons
round menus rather than select

1.7 shannon

process
information source → transmitter → produce signal
signal is modified by noise
received signal → receiver → destination

formula
C = H(signal) - H(noise) = W'log((S - N) / N)

shannon formulation
A is amplitude (of information source)
W is width (of target)
a and b are empiric values, use linear regression
movement time MT = a + b log (A/W + 1)
information source is the amplitude, width is the noise

determine a, b for device by varying A, W in experiments
adjust the target width such that 96% hits

1.8 extensions of fitts law

more dimensions
UI's are mostly 2D, buts fitts only 1D
can generalize the formula for 2D, 3D, ...

angular motions
consider rotations instead of linear motion
just replace A, W with angulars

steering law
predicts time for trajectory movements
fits nested menus, handwriting, ...

continuous steering law
steering along curve

1.9 applications of fitts law

evaluate input devices
empirically find a, b for different devices
compare devices
leads to optimized mouses

optimize user interfaces
empirically find a, b for UI
optimize UI elements for predicted movement times
leads to optimized keyboards

does not include
body asymmetries (left vs right hand, flexion vs extension)
parallelization strategies (two hands, multiple fingers)
cognitive factors (reaction time, searching time, ..)

2 Interaction Paradigms & Computational UI Design

2.1 UX milestones

mouse 1964, usable at 1983
touch sensing table 1985
smartskin 2002

idea growth
invention
refinement & augmentation
traction (when its finally used)

2.2 interaction paradigms

commands
directly typing in commands with the command line

dialogue systems
onscreen / speech-based dialogue systems

searching and browsing
list / grid with all items

direct manipulation rules
visibility of objects and actions (self-explanatory)
rapid, reversible, incremental actions (allows to recover)
direct, visual manipulation of object of interest (eases memorability)

2.3 emerging interaction paradigmas

context sensitive UI
knows where you are
predicts your next action

natural language interface
speech commands
AI & search still bad

AI UI issues
not self-revealing
difficult to understand what its capabilities are
severe novelty effect (only used at the beginning)
social acceptance issues
high cognitive load

augmented reality
quite old, but old phase was not successful
next phase probably now

2.4 UX livecycle

costly, unrealiable, slow, subjective, non-accumulative
multiple iterations often better than single idea
getting the design right (refine existing design to perfection)
and the right design (change approaches to overcome local minima)

analyze
understand user works and needs

design
create interaction design concepts

prototype
realize design alternatives

evaluate
verify and redefine interaction design

2.5 model-based UI optimization

designer proposes stuff (driven by design studies)
optimizer generates model (driven by computer science)
model is evaluated (by behavioural sciences)
then use model to create optimal user interface

2.5.1 in general

minimize sum
frequency of i used after k
effort from j to l
random variables i to j
random variable k to l
(random variables determine tested layout)

solve with
greedy (locally optimal choice)
dynamic programming
constraint programming
branch and bound

multi-objective optimization
includes additional possible factors
performance (speed, accuracy)
experience (satisfaction, aesthetics)
effort (energy consumption, fatigue)

2.5.2 linear assignment

frequency factor
entry value

effort factor
fix value 1

2.5.3 keyboard

frequency factor
use dictionary
use world frequency

effort factor
with fitts law
a + b log(D_ij/W_j + 1)

2.5.4 menu-optimizer

adapt keyboard optimization

include SDP
search (time to find item, increases linearly with items in menu)
decision (time to decide upon item, determined by experiment data)
pointing (time to point to right item, determined by fitts law)

consistency
pull same items together
penalize wrong positioned items
remove not matching items

frequency factor
number of items in menu
position of target menu
number of trials
decision entropy

effort factor
fitts law

3 experimental design

3.1 evaluation types

3.1.1 formative

early in the design process

understand the user
sanity check the right thing is built
observe and understand current processes
generalize observations into functionality
create scenarios for actual usage

prototype interfaces
low fidelity techniques (paper, video)
interactive (limited functionality in high level language)

3.1.2 summative

check if solution works, has been improved, compare with other solutions

measure quality
analytics (experts)
empirical (measure how well task is completed)

measure statements
less errors, faster completion time
check if target metric is reached on average

metrics
effectiveness, efficiency, satisfaction

3.2 study

cause and effect
cause has to precede effect
cause and effect need to correlate
all other possible explanations must be ruled out

infer causality
experiment where cause is present (independent variable 1)
control group where cause is not present (independent variable 2)
choose dependent variable (like grade)
show correlation

characteristics for empirical
objectivity, reproducible, relevance
external validity (good sampling, big sample sizes)

3.3 analyze data

how to analyze data?

view data
display max, min, n
mean (average over values)
median (number at middle of value)
mode (most frequent value)
range (value range, max - min)
check histogram (uniform, symmetric, skewed, bimodal)

representing error
sum of squared error (sumof diff value to median)
variance (divide by n-1)
standard derivation SD (root of variance)
standard error SE (SD divided by sqrt(n))

t-test
difference mean_test - mean_control, divided by SE_test

confidence interval
replicate experiment extensively
persist confidence interval
then do statistical tests with the confidence intervals

writing up results
define statistical procedure
describe samples with median, mean, confidence interval
describe difference with statistical values
visual representations

4 HCI studies

4.1 survey of statistical problems in HCI

60% fail to report data appropiately
30% use wrong statistical assumptions (use non-applicable tests)

30% do over testing (using same samples for different purposes)
20% do inappropiate testing
for published papers, in medicine report failure at 90%!
see wikipedia.org/wiki/Misuse_of_statistics

why
p 0.05 value is arbitrary
only results published (if something does not work, its not published)
lack of awareness

problems with bigger samples
more participants stabilize slowly, therefore costly
better measurements can also help to increase power

robustness
statistical analysis robust when similar datasets create similar results
plot robust when difference clearly visible
interpretation robust when similar datasets imply similar interpretations

possible solutions
prohibit usage of p values to draw conclusions
researchers should refrain from final conclusions

4.2 study fundamentals

within subject design
everybody does everything
each subject sees all independent variables
need to permute presentation order to avoid learning effects
full randomization implies n! groups, use latin square counterbalacing
shift condition by one place per row, reorder rows, reorder columns

between subject
only one condition per group
each subject sees only one independent variable
need to balance groups to account for different skill levels
personal interviews or random assignment

independent variables
what is compared
categorical (unordered discreet, countries)
ordinal (ordered discreet, month)
cardinal / interval (continuous values, height)

dependent variables
what is being measured
precise, unambiguous measurements
collect quantitative feedback (how many, how much)
difference between behavioural (what is done) and attitudial (what is said)

extraneous variables
what else is varied, but can't be accounted for
gender, age, nationality

4.3 how to do a study

goal of study (what to investigate)
set a research question

study design
define a goal, set a research question
define how to evaluate your research question
what is being compared (independent variables)
what are they compared with (dependent variables, metrics)
what is being varied (extraneous variables like age)

subjects design
within design (but need to counter balance to avoid learning effects)
between design (but need to account for different skill levels)
define sampling (for example convenience sampling)

measurement design
define metrics to measure your research question
think about multiple data sources
find effects in different sources (triangulation)

possible metrics
number of keystrokes, mouse clicks, page visits
self-reported values, observations
task completion time
error rates

standardized questionnaires
NASA TLS (perceived task load)
SUS (system usability scale)
UEQ (user experience questionnaire)

study procedure
what participants need to do
create a handout with detailed instruction
define what has to do before the task
how the task has to be done
what has to be done after the task
include open questions
include section for experiment conductor (starttime, endtime, notes)
include section at the end to say thanks

study evaluation
define how the measures will be tracked

study hypothesis
define whether qualitative (explain) or quantitative (measure)
define hypothesis and their reasoning

organisation
ask people personally if they want to sign up
use a nice tool for them to register (for example typeform)
shortlink to pass around
confirm event personalized
bring something to eat
lottery if unable to pay participants
"thank you" email with results of study

write report
use standard format like apa6
abstract for a short summary
introduction section contains motivation, explains product / functionality
methods section explains how study was performed
results section visualize quantitative results (p values, graphs)
discussion explains qualitatively the seen results (why, how to fix)

4.4 interaction design

applies to desktop, mobile, web pages, ...

aiming
support users rather than replacing them
enrich the user experience
10 minute rule (learn & use time for new users)

identify users
all stakeholders
study setting, not individuals

general process
requirement analysis
prototype continuously adapted by evaluation results
evaluation with studies

design process
establish requirements
develop conceptual model (define interaction)
produce rough models
experiment with alternatives

scenarios
informal narrative descriptions
"real world" events and the resulting interaction
develop into use cases
maybe create storyboards
establish requirements with customer

sketches
quick, plentyful, disposable
clear vocabulary (not an implementation)
constrained resolution (capture only the concept)
refinement keeps concepts

prototypes
turn sketches into interactions
can use paper (cheap, encourages creativity)

workflow to working system
brainstorm different ideas (lot of sketches)
choose idea, and create rough interface (sketch variations)
task centered walkthrough (low fidelity prototypes)
fine tune interface with heuristic evaluation (medium fidelity prototypes)
usability testing (high fidelity prototypes)
limited field testing, alpha/beta testers (working system)

some targets
rewarding, aesthetically pleasing, motivating, helpful, enjoyable, satisfiable
efficient & safe to use, easy to learn & remember, good utility

design principles
visibility (show action user wants to perform)
feedback (visual, audio, tactile reaction of what is happening)
constrains (restrict actions to reduce errors)
mapping (natural control-action connection)
consistency (same workflows, grouping)
affordances (give clue of what is going to happen)
simplicity

text
novice readers assemble words letter per letter
advanced readers skip assembling
avoid repetition and long paragraphs
avoid centred text

considerations
allow for colour blindness
only small part is actually seen sharp
attract attention with movement or colour to important information
continuity (eye completes image)
figure / ground (eye assumes something to be in the front)
remind users of their actions (persist search query, use adaptive UI)
don't expect users to remember (show current step / progress, cleanup)
recognition easier than recall (shortcuts harder as finding menu element)
provide visual cues (show preview, show past actions)

visual hierarchy
organize content using size, prominence, content relationships
vary text size, bold, order, grouping
use spacing and hierarchy for structure

gestalt laws
emergence (form complex pattern from simple rules)
multistability (figure/background selection)
reification (brain assumes more content as explicitly shown)
invarriance (3D recognised in 2D)
closure (complete shapes)
similarity (similar objects form group)
proximity (close objects form group)
continuity (assume overlapping objects are simple shapes)

4.5 paper prototyping

steps
create user profile
decide on task
create prototype
perform walkthrough
plan study

good task
critical for product
goal that matters for user
finite set of solutions
clear ending point

run study
facilitor (guides the process)
computer (simulates the system)
observers (document the study)
helpers (provide help if asked to do so)

construct paper prototype
list screens for each task and create them
break down screen into elements (can be switched)
hand-drawn vs screenshot mix

good at
find issues with requirements
detecting unclear concepts
problems with navigation, workflow
define documentation and help requirements
find issues with layout

bad at
find interaction issues
input methods (like scrolling)
response time
animations

4.6 video analysis

why
observing users can be more revealing than asking them
revisit scenes many times, focusing on different aspects
collaborative analysis

captures
basic actions
verbal communication
facial expressions
gestures, body movement
gaze

gain access
management (in their interests, no interference with work)
workers (get insight into skills / issues, say not about optimising)

ethical considerations
informed (everything which may occurs is disclosed)
consent (rational, mature, voluntary agreement, free from pressure)
formal informed consent required
give time to ask questions
inform detailed in public places
agreement of parents in schools
preserve privacy (blur, remove sensitive remarks)
determine how data is stored (time, place, usage, access)

recording
sample recordings
wide angle captures scenes but loses details
short-angle captures interaction but loses expressions
external micro often required

get users to speak
ask users to think aloud
work in pairs to hear discussion of problems

structuring data
preliminary catalogue, describing all interviews which took place
transcribing segments for future reference
transcribing visible conduct for future reference

4.7 touch

FBTouch
basic touch optimization, multi-touch extensions
touch-enhanced interface (more spacing)
touch event handling
touch event tracking with easy matching
touch event capture and delegation
touch device detection

W3Touch
logging, inspection, segmentation, adaptation
rather poorly optimizes non-mobile sites for mobile

4.8 cross-device applications

4.8.1 eye-free pen interaction

what
handheld mobile device which can change colours, erase, stroke, undo/redo
use pen to "write" on whiteboard
recognised stroke then projected on whiteboard

study
compare three UI's
eyes free uses touch gestures to command
classic uses big buttons
popup was displayed on the whiteboard

study process
design (conditions, tasks, questionnaires, measurements)
implement (study setup, adapt software, logging)
pilot (test issues, time, instructions with pilot subjects)
recruit (find participants, schedule appointments)
run (keep conditions stable, collect data)
report (statistical analysis, interpret results)

study results
eyes-free & classic faster than popup
no other significant results

study problems
participants used classic UI also eyes free
too few participants
not so great logging

4.8.2 cross device testing

what

can debug on different device connected by wireless
shared css / javascript editor

study
can't do proper study cause no time
instead 2-hours lab study with inexperienced developers
browser debugging tool as baseline
prepare remote debugging
two tasks to solve, one rather easy
recorded video, questionnaire, measured time, code written by participants

study results
participants liked tool

study problems
tasks not well balanced
not all features under test were used
participants were bad at judging their skills

4.9 digital pen & paper

to bridge paper-digital divide

automated form processing
pen strokes captured and stored on pen
data uploaded to pc

paper point
control powerpoint with printout
free pages for free drawing

multimedia pen
capture audio, real time processing

iPaper
create active areas inside pdfs and link to multimedia

EdFest
tourist guide with paper documents & pen
interactive event brochure
can rate attractions, navigate on map
noone cared
lack of clear goals & hypothesis other than impress
lack of collaboration with designers, systems people
lack of frameworks made the application way to complex
needed nearby laptop to function properly (lol)

Print-n-link
use digital services to search/retrieve cited publications

PaperProof
edit on paper, changes are reflected on computer

iGesture
draw gestures on paper, which will then be executed on pc

iTable
map projected on table, can be written on

4.10 adobe lightroom

easy to use photoshop
task-based, modular

different applications
wedding (post-processing, publish to webpage)
landscape (well prepared, filters & post-processing)
studio (well prepared, direct review, post-processing)
wildlife (catching the moment, lots of pictures)
sports (review in short time)

first phase
user interviews (phone & personal visits)
walking through the activities of recent photo shoot
starting with high-level overview of last job, then communicating
timeframe to discuss certain activity

impact of first phase
general framework for workflows in the real world
users were patching together wide range of tools
found out which feature of PS are crucial

define task based environment
used card sort to ask photographers how workflow should be structured
0. cards with tasks written on are given
1. exclude all cards which were not applicable
2. add new cards with missing functionality
3. grouping, duplicating & arranging cards
4. creating names for the groups
5. repeat 1&2 for feature cards
6. add the feature cards to the task groups
highly consistent workflows & features used could be shown
summarized results on poster

key features lightroom
workflow top right (library, develop, slideshow, export)
user driven attributed (mark images)
faceted search & metadata (search by tags, labels, attributes)
in place image manipulation (marking, moving)
different visualization (fast change UI layout)
organize images into folders
select images based on ratings
compare images
simple post-processing
export as slideshow, print, web

online interview
general background questions
scalar agreement questions (likert scale)
multiple choice questions
open questions

online interview considerations
personal information can be sensitive
ask at the end of questionnaire as user more likely to answer
provide slider/ranges where applicable
recruited using social media
offer reward if it does not distort subject group
as short as possible
only few open questions
no jargon
what to do if running issues contains mistakes

study results
browsing folders more common than search
keywords, smart collections not often used

4.11 communications

everybody communicates; denying communication also communication!
not only worlds but also meta-info exchanged depending on speaker and target

4.11.1 rules of conversation

next speaker starts talking, current speaker continues or chooses next
next speaker chosen by asking question, making request, inviting opinion

4.11.2 irritation

if rules disobeyed, interrupt constantly, ignore cues

4.11.3 specifying length of talk

state length explicitly, or finish with explicit sentence
shift body, change focus, use gestures

4.11.4 adjacency pairs

multiple concurrent conversations in one using phrase pairs
first phrase determines which conversation continues

4.11.5 new forms of communication

e-mail (clear turn taking, one to many, recipient controls pace)
emoticons (clearly communicate intention of sender)
social media (supports, relationships, lightweight conversations)
rich media (face-to-face communication like video calls)
lean media (text-only chat)

4.11.6 collaboration

task-related goals with known team of small size
collaboratory are big collaboration groups
emails, calls, conferencing, shared files
goal-directed, time-limited, identified parters, assigned tasks, cross-review

4.11.7 effective collaboration

abolishing emails may help
social media for workplace
simple tools as doodle can be very effective

4.11.8 crossover

wikis, blogs, chats

4.11.9 social media

tagging, rating, review
large scale

playful, unknown parters, act independently

4.11.10 crowdsourcing

large-scale collaborations
unclear motivations, quality, ethical, social implications

4.11.11 effective crowdsourcing

use algorithms which allow concurrent editing, undo/redo
use privacy sensitive environment (explicit push of changes, not WIP)
awareness of others work helps to avoid conflict

4.11.12 awareness mechanism

awareness visualization (displays who did what)
awareness computation (finds out who did what)
consistency algorithm (sync stuff)
structured document (allows concurrent editing)
operations (persist actions performed)

4.11.13 organisation forms

face to face interactions
same place / same time
use presentations, whiteboards

continuous task
same place / different time
project management, team rooms

remote interactions
same time / different place
video, chat, screen share

communication / coordination
different time / different place
emails, blogs, shared files, forums

4.12 ambient information

inform without distracting (like steps in house warn of arrivals)
easy switch between periphery and centre of attention
nice to know, non-distracting, push rather pull

communication zones
device with interaction, notification, ambient zone
active zone depending on distance of observer

examples
informative art (image different depending on ambient)
info canvas (user chooses visualization if condition met)
composition (coloured, sized squares visualize weather)
live wire (moves faster if more bits in channel)
AuraOrbs (bubbles visualize presence of coworkers)
medication boxes help to remember
umbrella lights up when ugly weather outside
light buildings according to events happening inside

5 other input methods

5.1 beyond mouse and keyboard

5.1.1 mobile spread

mobile are more common than desktops
responsive design focuses on adapting content rather than different modes of interaction

5.1.2 developers study tilt-and-tab

js library for recognising tilt and tab gestures

goal
easy to use according to developers

task
create slideshow
small tasks including all major features
group work like real company
larger number of participants
but maybe only part involved, no lab environment

participants
web students
perfect set of skills, but forced to do the exercise

evaluation
grade of exercise, questionnaire
lot of feedback, but not allowed to link grade/feedback

5.2 gestures

form of non-verbal or non-vocal communication in which visible bodily actions communicate particular messages
motion of the body which contains information

types
symbolic (single meaning within culture)
iconic (about size, shape, orientation)
pantomimic (use of invisible object)
deictic (specify object, directing attention)

define a good gesture
design (by developer or user)
memorability (how well remembered form / action)
consistency (in form and action)
customization (how users customize it)
registration (part-gestures recognition)
segmentation (when it starts/end)
conflict (distinguish from others)
completeness (all actions covered by set)

5.3 psychology

Inattentional Blindness
attention is directed to different things; big changes can go unnoticed
unusual changes hard to detect (like fading building facades)

Perceived Dominance
perception of factors such as power, intelligence based on appearance
height, age, facial features