

IST VIVAGO®

Activity monitoring



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1. Circadian rhythm and Sleep
2. Activity monitoring and Vivago system
 - Technology
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Consultants:

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Circadian rhythm and Sleep

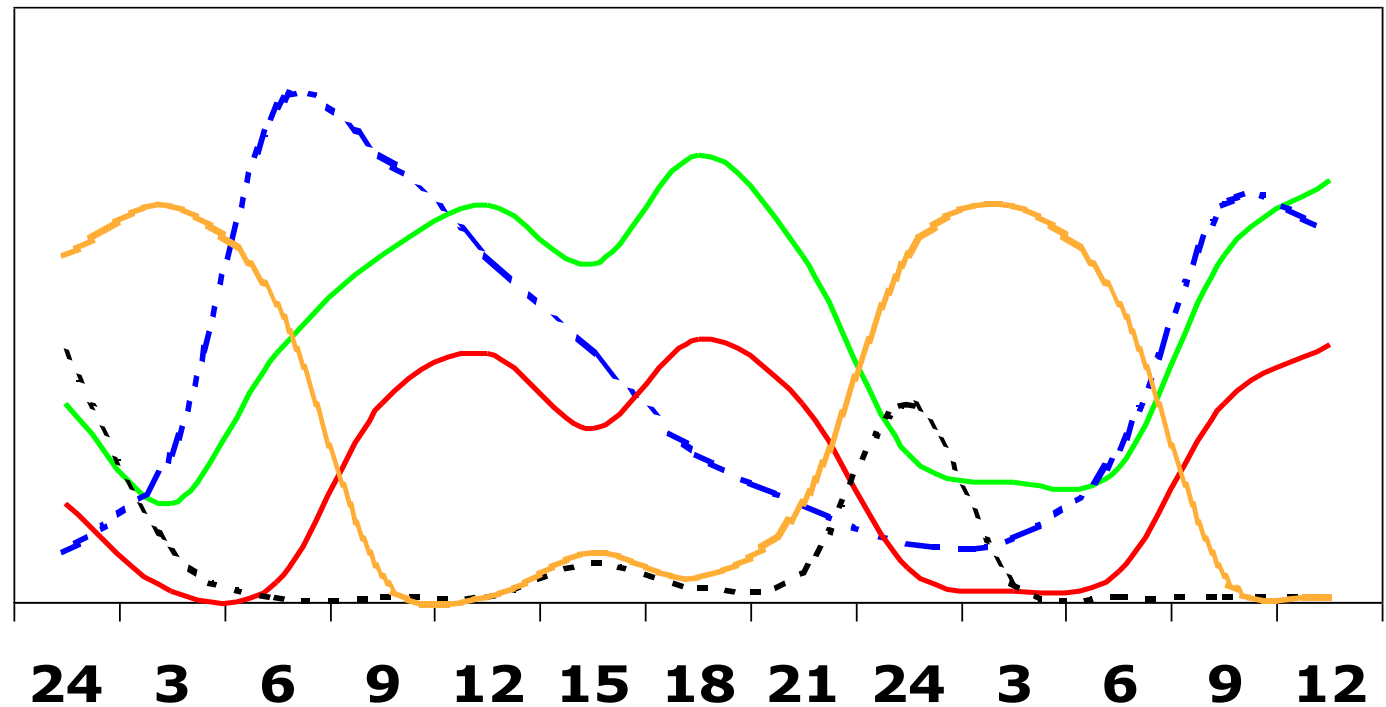


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Biological circadian rhythms



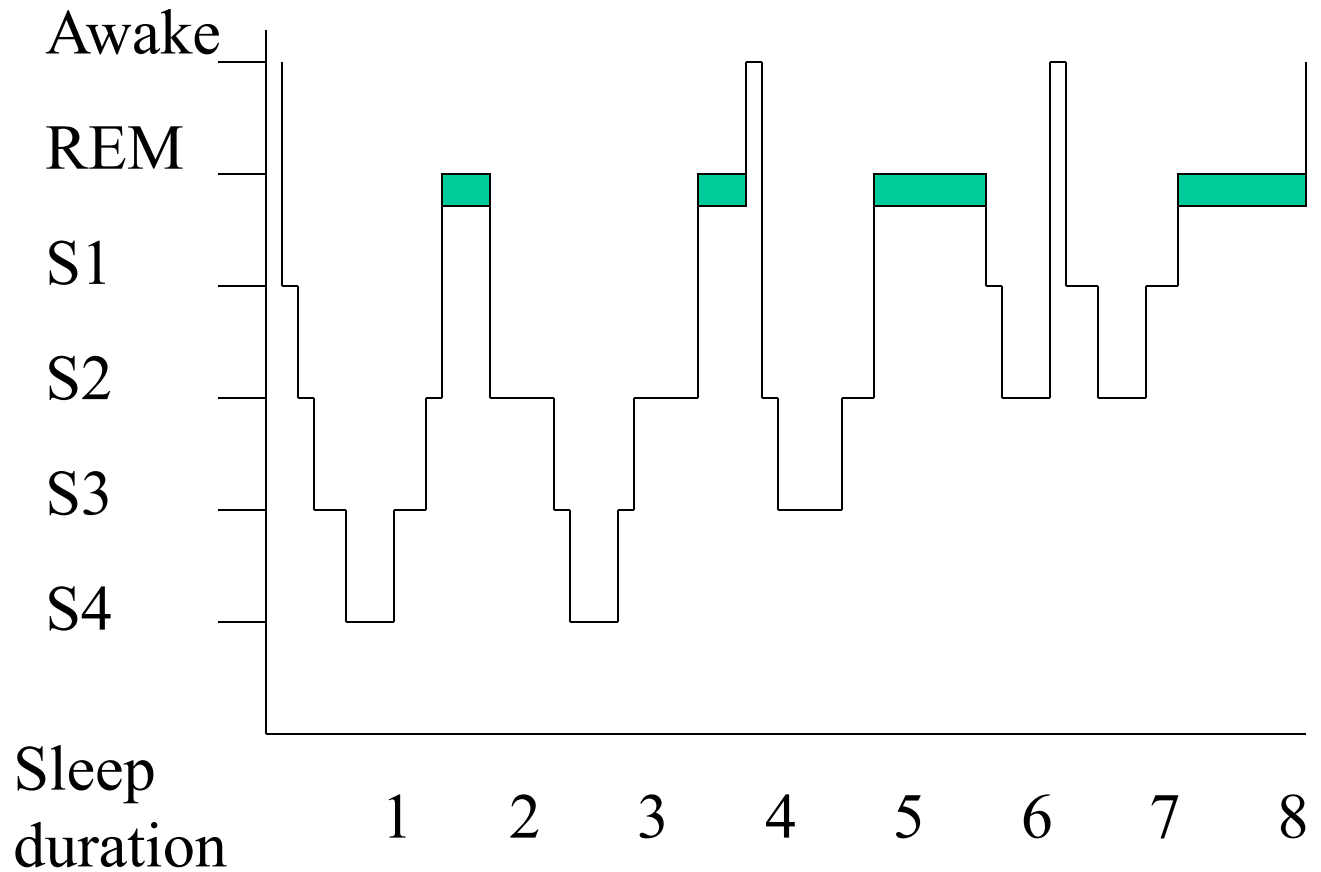
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Sleep stages



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Why we sleep?

- Obvious answer:
“to stay alert and awake”
- Physiological answer (SciAm 11/03):
 1. Reduced brain activity during non-REM sleep gives the brain cells a chance to repair themselves
 2. REM sleep allows specific brain cell receptors to recover – helps with the regulation of mood and learning
- Sleep is necessary to ensure the recovery of brain functions and to maintain physical activity and cognitive ability.



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Sleep and health

- Sleep is vital for health and well being
 - Sleep deprivation affects negatively hormonal balance, immunity system, and metabolism
 - Example: Chronic sleep problems increase the risk for obesity and type 2 diabetes
- Sleep reflects the person's health status
 - Example: Insomnia is a typical symptom of stress



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Sleep of the elderly



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- The amount of sleep needed stays roughly constant through life
- The sleep becomes lighter and more fragmented
- More night time awakenings
- Early bedtime leads to an early wake up -> advanced sleep-wake cycle.
- Sleep disturbances are very common

Sleep disturbances of the elderly



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- 40-70% of the elderly population suffers from chronic sleep disturbances, but 50% of the cases go unnoticed by the primary care physicians.
 - ⇒ results in decreased daytime alertness and increased tiredness
 - ⇒ increase the risk for falls and accidents
 - ⇒ strongly affect autonomy and self care
 - ⇒ compromise the general well-being
 - ⇒ increase in chronic sleep medication
- Doubles the number of sick days, increases the need for home help, community nurses, day centers, hospitalization and other health services

E.J.W. Van Someren: Circadian and sleep disturbances in the elderly, *Experimental Gerontology* 35 (2000)

Reasons for disturbed sleep/wake cycle

- Sleep disorders
 - Sleep Apnea
 - Restless legs
 - Delayed – advanced sleep cycle
- Other diseases
 - Circulatory disorder in brain or extremities
 - Alzheimers disease and other dementia
 - Parkinsons and other neurological diseases
 - Backache and other neuromuscular diseases
 - Chest pains, cardiac failure and asthma
 - Continenace failure
- Temporary reasons
 - Excessive use of coffee, tee, or alcohol, smoking
 - Medication (heart, hypertension, asthma etc.)
 - Erroneous sleep medication
 - Too long daily naps
 - Environmental reasons: noice, light, etc.
 - Mental reasons: depression, sorrow, loneliness
- Note! The IST wrist unit is not a medical device, and only monitors activity, not a specific disease or illness!



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Methods for avoiding and treating sleep disturbances



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- Treatment of underlying health problems (physical and mental) that affect sleep
- Lifestyle issues:
 - Physical exercise - an active day contributes to better sleep quality
 - Proper environment for sleeping (temperature, lights etc.)
 - Avoid stimulants, alcohol etc.
 - Reserve the bed for sleeping
 - Regular sleeping habits
 - Avoiding the chronic use of sleep medication

Summary

- Regular circadian rhythm and good sleep is essential for the well being of the elderly
- A method to continuously and remotely monitor sleep would bring an important tool for the elderly care



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Solution:

Activity Measurement and Monitoring with Vivago System



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Activity measurement technology



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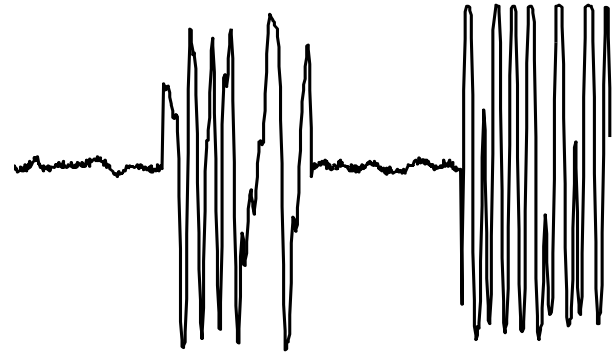
Vivago signal



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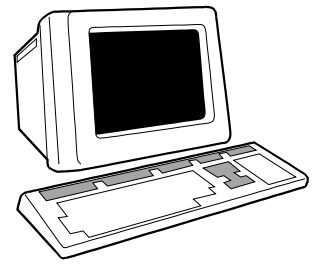
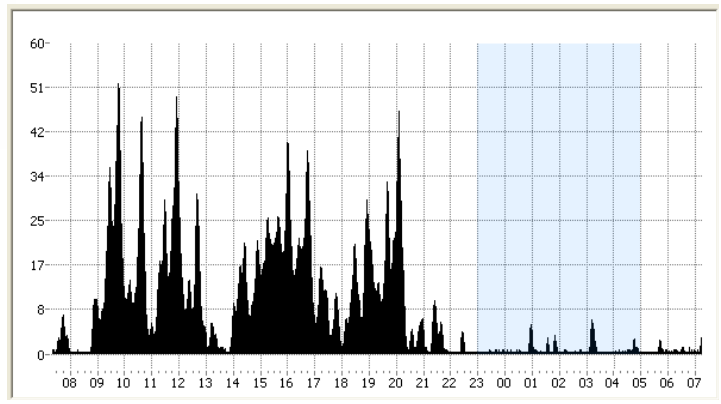
← 1 min →



Hands on table Knocking table Handwriting

**Wireless
data
transfer**

**Signal
processing**



**24h activity curve display on PC screen
depicts sleep and circadian rhythm**

Institutional system



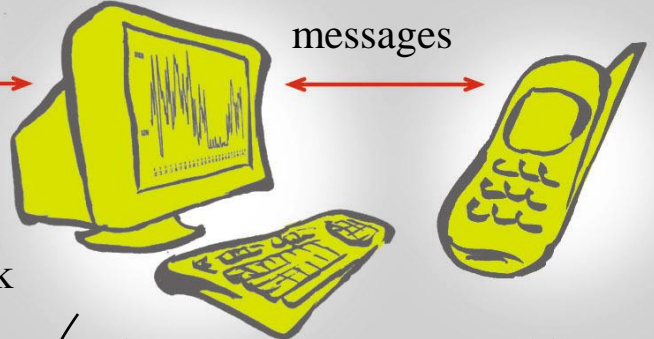
Wrist Units



Common base stations in hallways



Voice/text messages



RF

Serial network

Vista-program

Mobile or DECT - phones

Device Interface modules



Alarm and curve displays

Alarm and curve displays

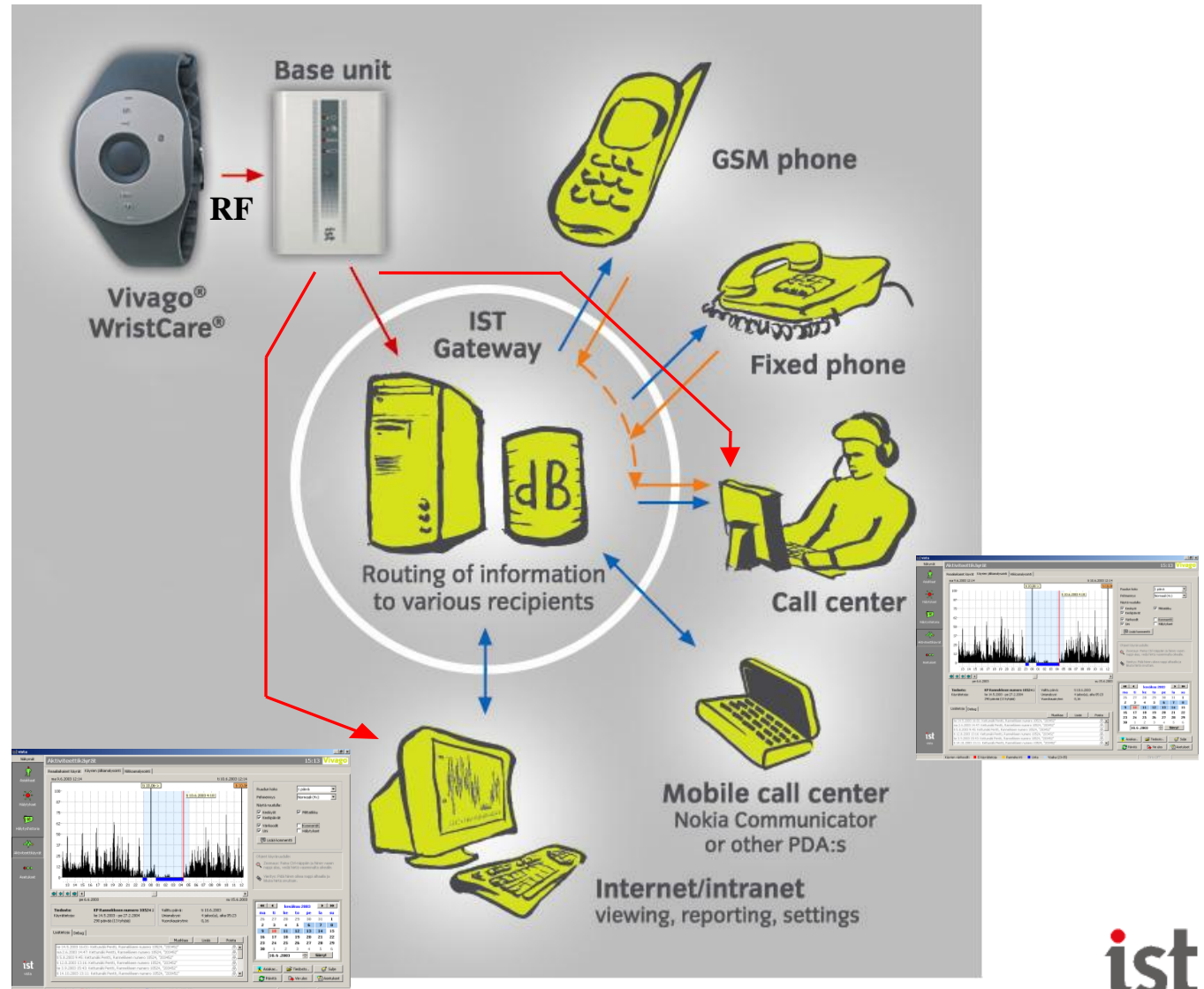
The screenshot shows the 'Vista' software interface. On the left, there is a sidebar with navigation icons for 'Alarm', 'Activity', and 'Settings'. The main window is titled 'Aktiviteettikäytöt' and contains a table of alarm events and a signal curve graph.

Date	Time	Alarm	Customer	From	Acknowledgment
pe 20.9.2002	11:00	Multi-link network lockout		test alarm	
pe 20.9.2002	11:12	Multi-link network lockout		equipment failures	
pe 27.9.2002	8:22	Multi-link network lockout		test alarm	
pe 27.9.2002	8:24	Multi-link network OK		kaatumuksen	
pe 27.9.2002	8:26	Alarm acknowledgment	Jarna Niemela (Dno 1)	WC oven alarm	
pe 27.9.2002	8:30	Manual alarm	Juhanna Heimon (Dno 1)	external threat	
pe 27.9.2002	8:30	Manual alarm	Jarna Niemela (Dno 1)	wrist unit too loose	
pe 27.9.2002	8:29	Manual alarm	Juhanna Heimon (Dno 1)	kaatumuksen	
pe 27.9.2002	10:00	High activity	Juhanna Heimon (Dno 1)	fallen down	
pe 27.9.2002	10:12	High activity	Juhanna Heimon (Dno 1)	cardreader alarm, com	
pe 27.9.2002	10:23	High activity	Juhanna Heimon (Dno 1)	stairs or att	
pe 27.9.2002	11:24	High activity	Juhanna Heimon (Dno 1)	reached the	
pe 27.9.2002	11:35	High activity	Juhanna Heimon (Dno 1)	were or att	
pe 27.9.2002	11:50	Manual alarm	Jarna Niemela (Dno 1)	alarm	
pe 27.9.2002	15:20	Manual alarm	Jarna Niemela (Dno 1)	for finding sm	
pe 27.9.2002	15:41	Low activity	Juhanna Heimon (Dno 1)	ok	
pe 27.9.2002	15:56	Manual alarm	Jarna Niemela (Dno 1)	user eventually panic	
pe 27.9.2002	16:16	Low activity	Jarna Niemela (Dno 1)	wanted ressource	
pe 27.9.2002	16:21	Manual alarm	Jarna Niemela (Dno 1)	Number	
ma 1.11.2002	11:06	Manual alarm	Jarna Niemela (Dno 1)	fallen down	

The graph shows a signal curve with a peak at 10:00 on 10.9.2002. The interface also includes a calendar and various control buttons.



Home system



One system – many functions

Apart from the manual alarms available in traditional care phones, IST's product features are:

- Automatic alarms of prolonged passivity and abnormal immobility
- Real time, remote and long term activity curve graphing for monitoring of users' sleep-wake rhythm
 - Sleep –wake rhythm is a sensitive signal reflecting the well-being of the elderly
- Intelligent wandering detection (e.g. for demented patients)
- Detection of wrist unit removal
- Self-diagnostic alarms

All features can be activated and deactivated by remote programming; no visit necessary to the user's home.



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Patented technology

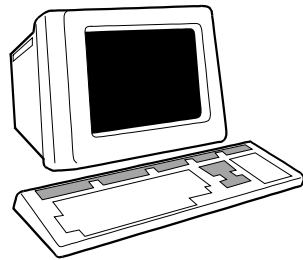
Main patent families:

- EP0724402 & US5670944
 - Body held monitoring device for physical condition
- EP1068599 & US6331816
 - Automatic control system for security apparatus based on the presence of a user
- EP1068602 & US6348867
 - Control system for building automation controlled by human physiological signals

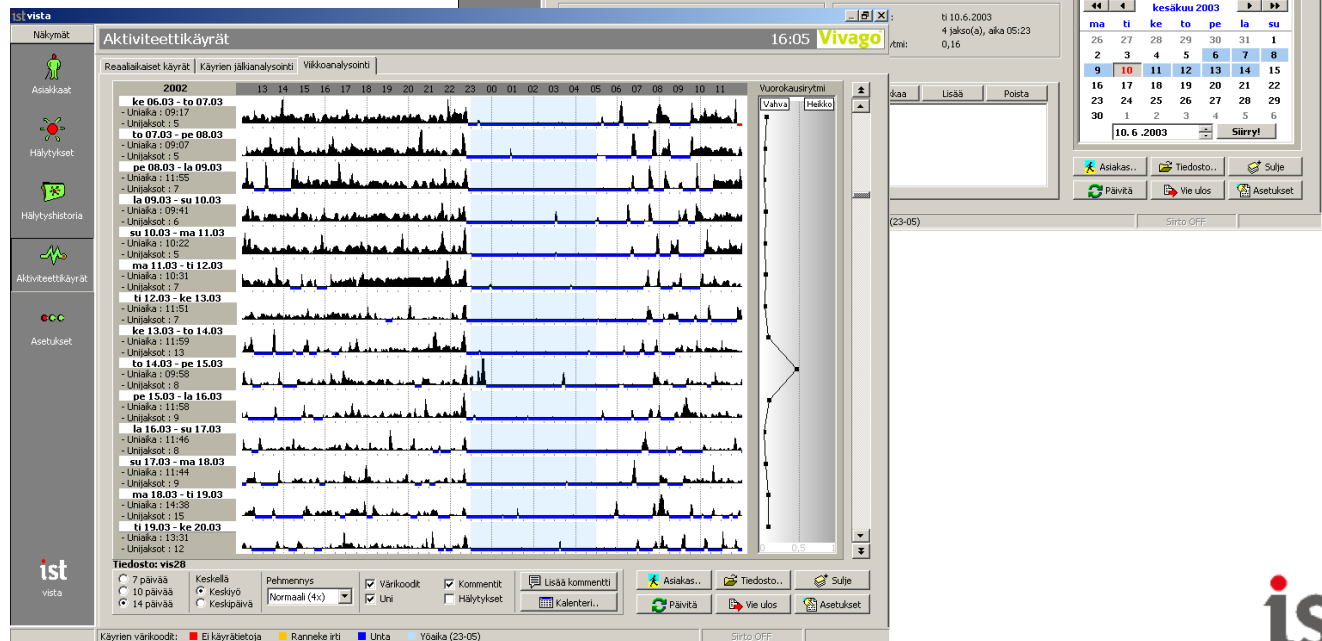
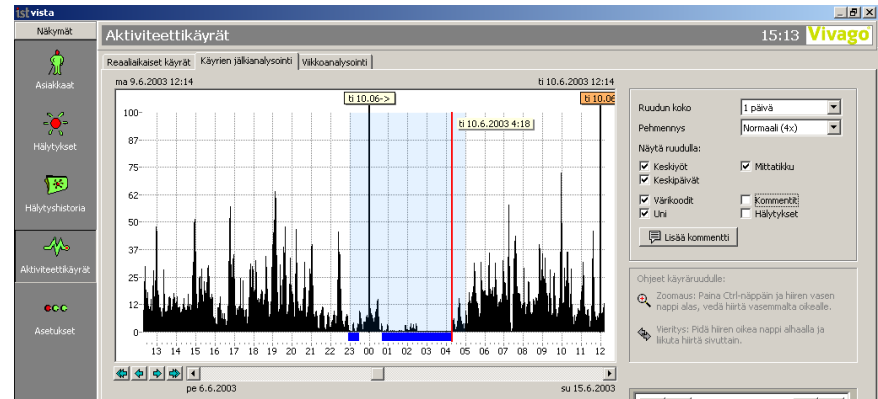


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VISTA software for analysing the activity curve

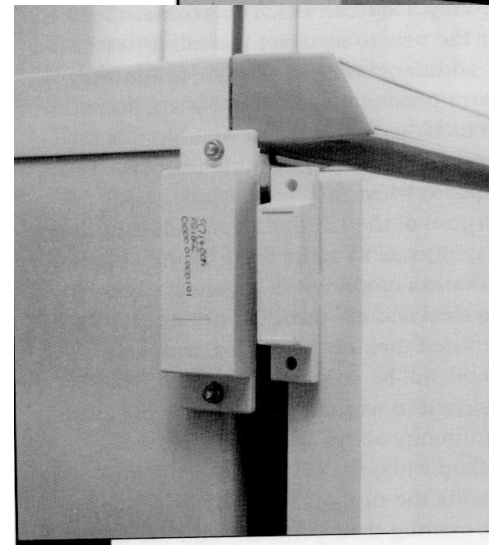
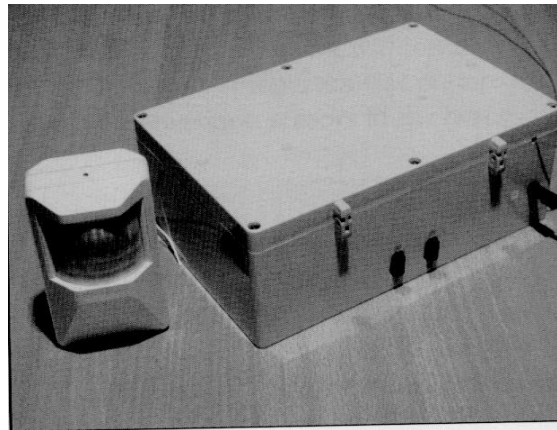
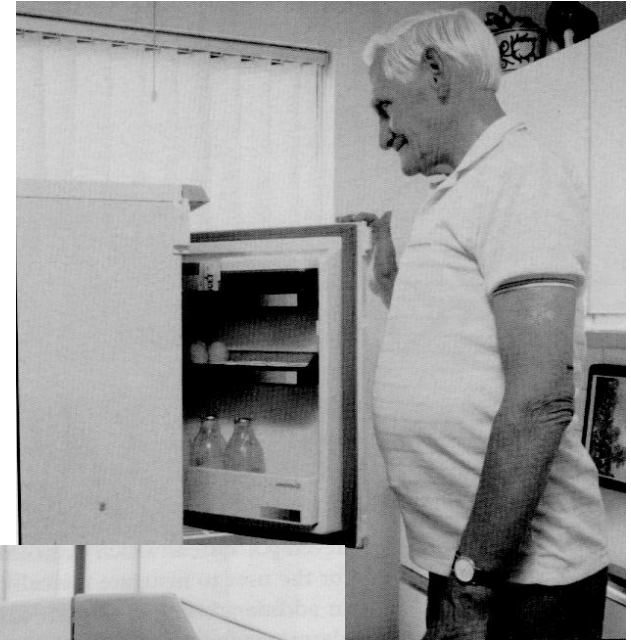


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Traditional monitoring of activity for alarming purposes

- embed activity monitoring into housing
 - movement detectors, switches, etc.



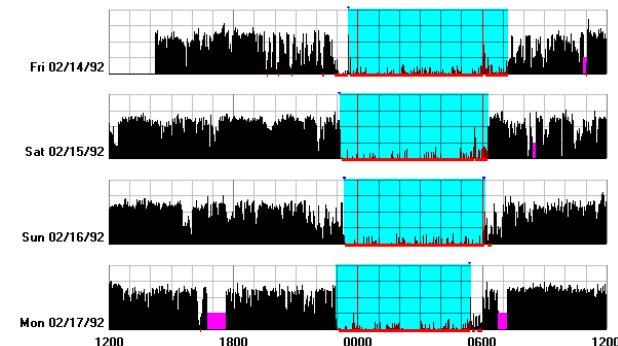
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Actigraphy: measurement technology

- **Actigraph** = small, wrist-worn device that measures movement
- Dataloggers, no on-line connection, no alarms, battery lifetime few weeks, expensive
- Used in clinical sleep laboratories to measure and analyse sleep - wake rhythm
- Hundreds of published scientific studies related to actigraphy



**Data download
via cable to PC**



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Polysomniography (PSG) vs. actigraphy

- Golden standard in sleep studies
- Actigraphy agreement rates with PSG in normal subjects ~90% (minute by minute)
- Total sleep time (TST) estimation with average error ~15min
 - However, error may be much higher in individual cases!
- Lower agreement if sleep or movement disorders or artifacts



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Activity curve, monitoring and analysis

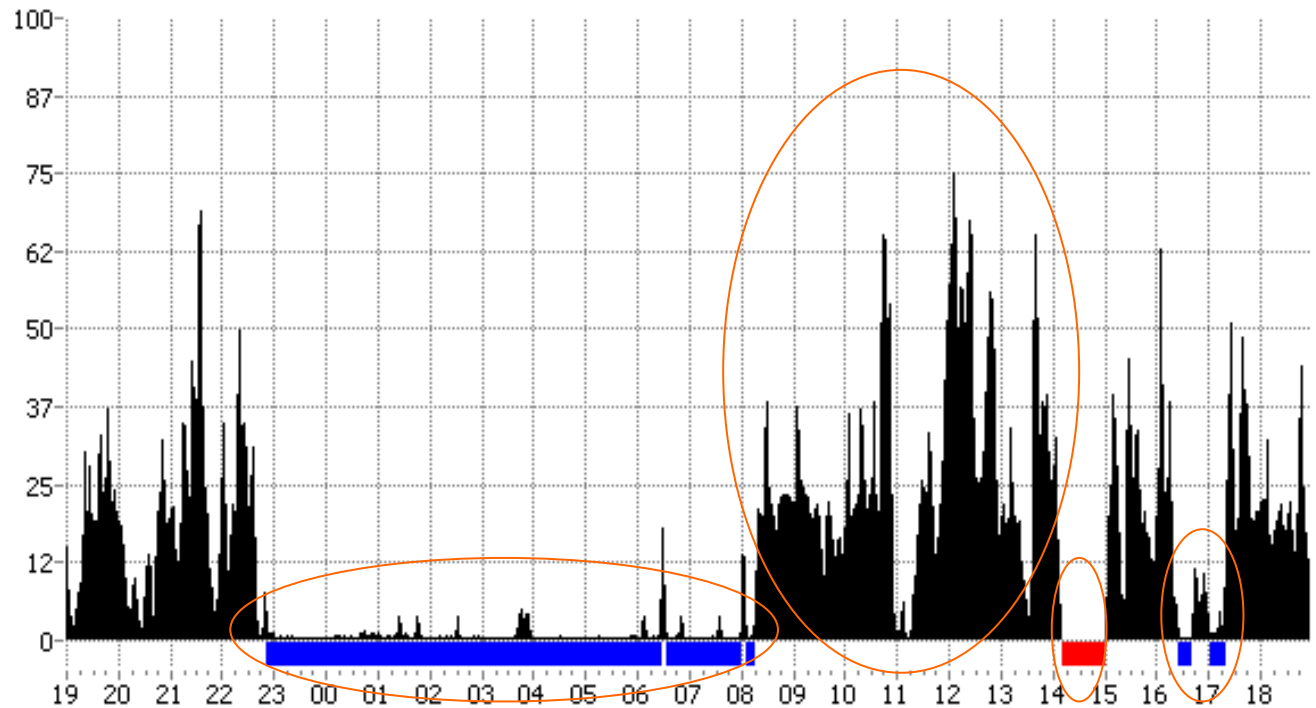


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Normal 24h activity

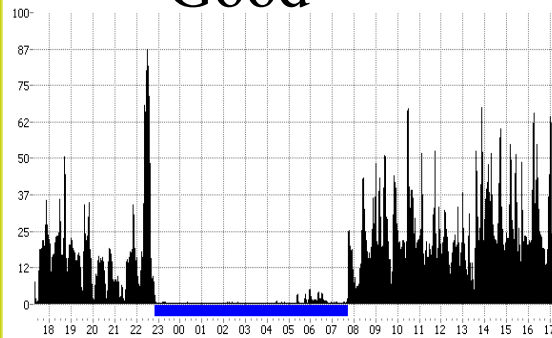


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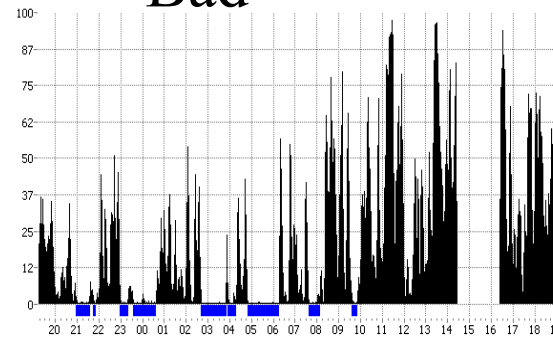


Main activity patterns

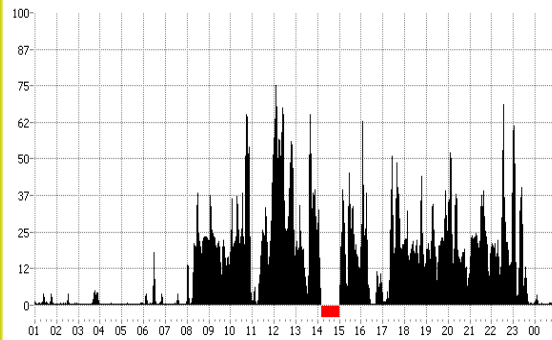
Good



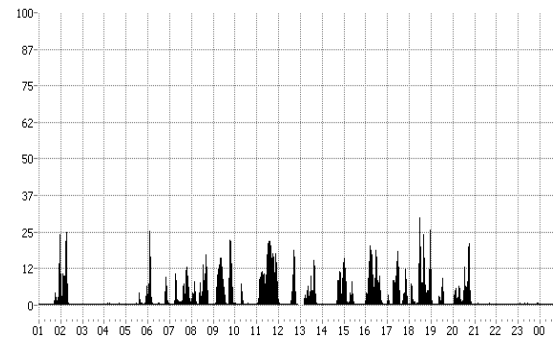
Bad



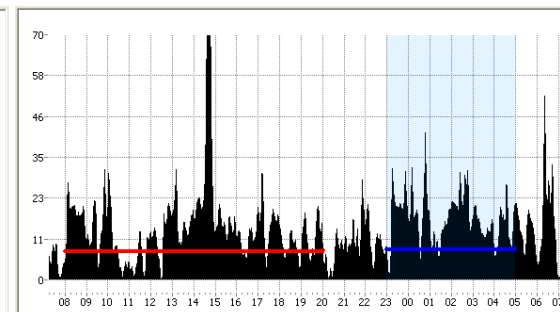
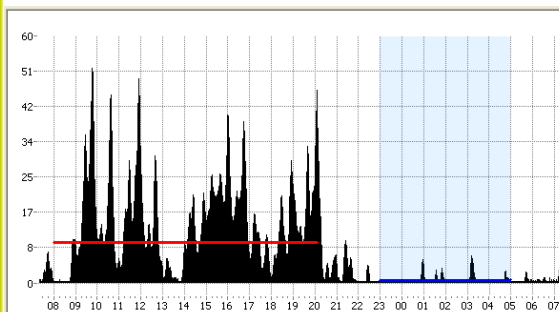
SLEEP



WAKE



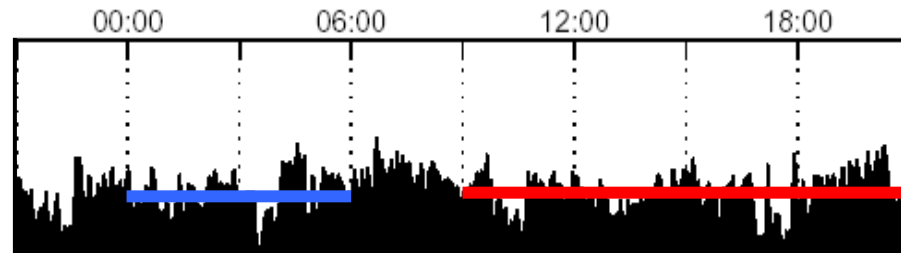
RHYTHM



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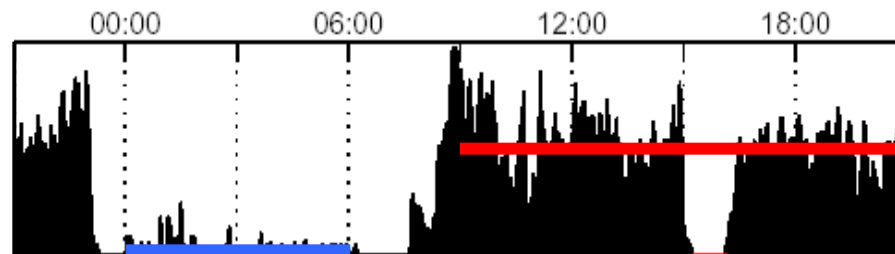
Night/day ratio

Poor rhythm -
night and day close
to each other



$$\text{Night/day}_{\text{mean}} \sim 1$$

Good rhythm -
night and day have
different activity

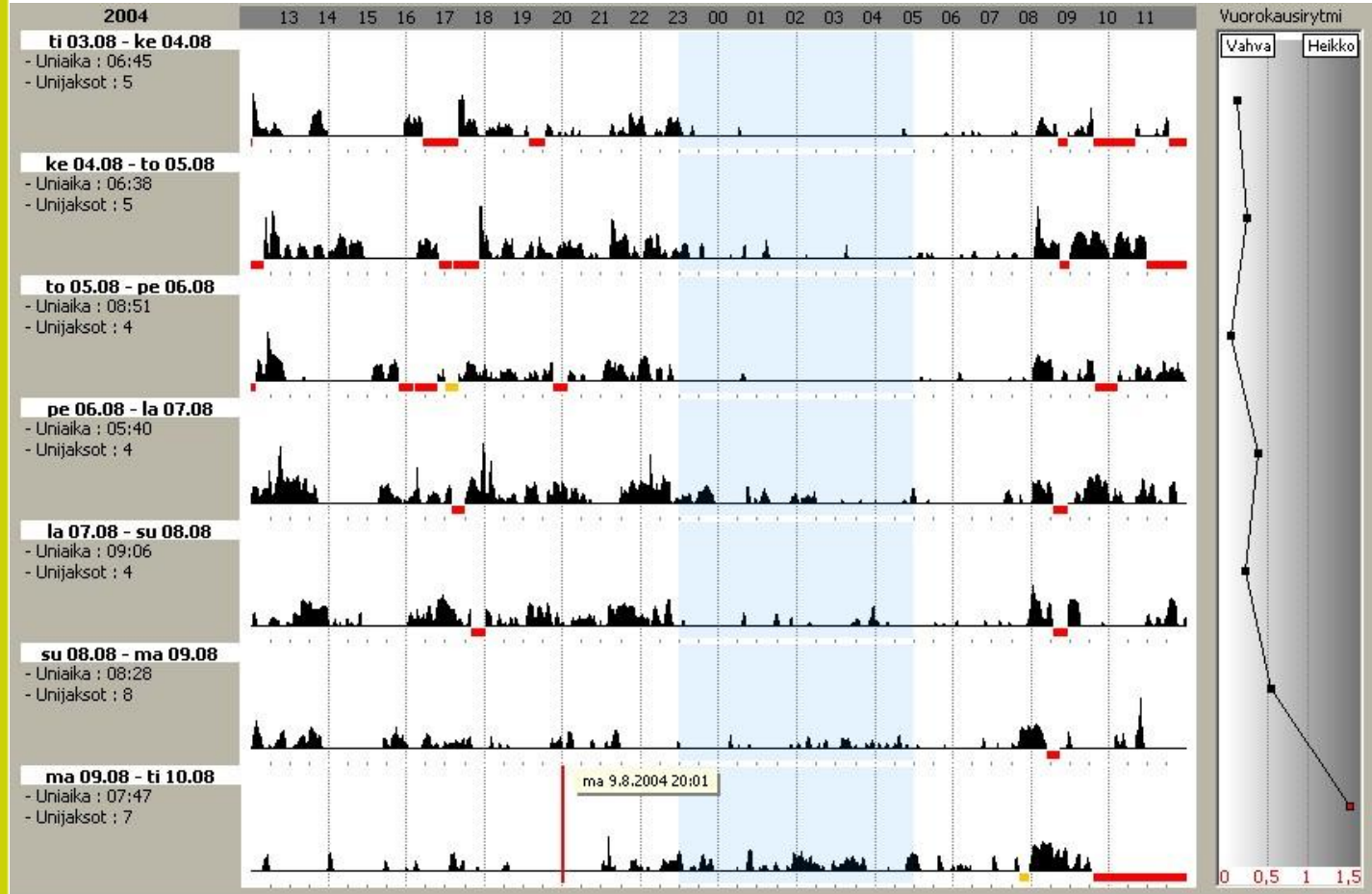


$$\text{Night/day}_{\text{mean}} \ll 1$$

Example: fast weakening of the day-night rhythm (caused by an urinary tract infection)

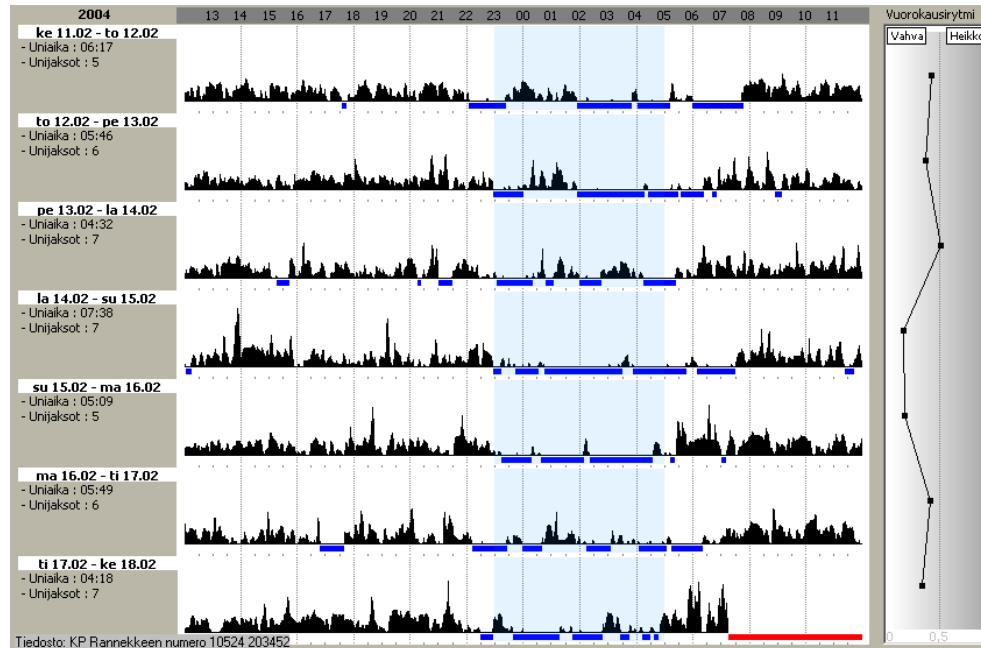
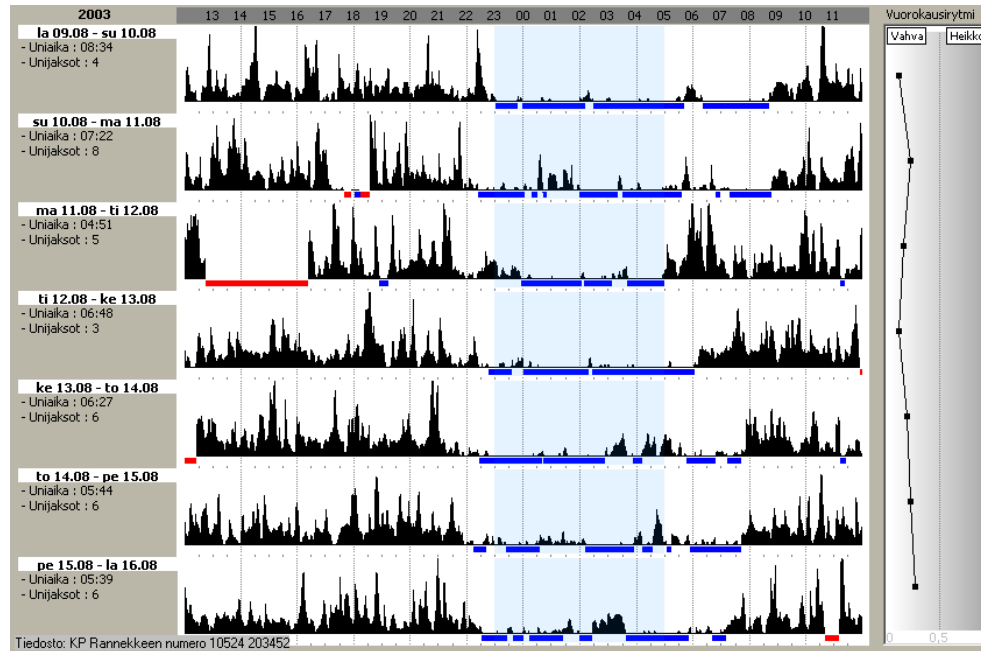


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Example:
slow
weakening
in the daily
activity
(caused by a
lung disease)

Activity curve monitoring and analysis, applications in elderly care



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- 1. EARLY AND REMOTE DETECTION OF PROBLEMS RELATED TO WELL-BEING**
- 2. TREATMENT FOLLOW-UP**

SLEEP-WAKE RHYTHM IS A SENSITIVE SIGNAL REFLECTING THE WELL-BEING OF THE ELDERLY

Activity curve monitoring, other practical applications

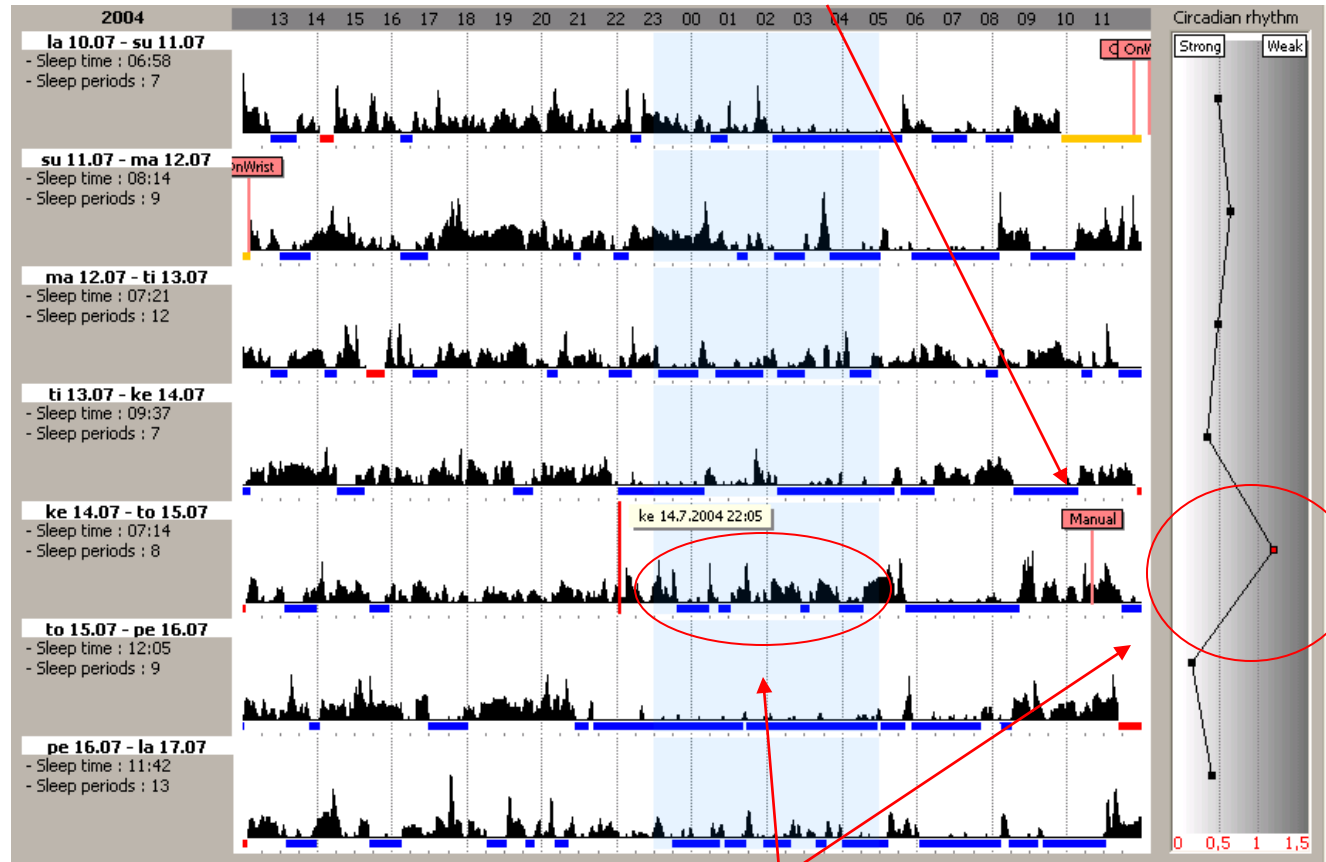


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- Advantages for the service provider:
 - relatives (or the customer) can see the state and development of the sleep wake rhythm and physical activity -> assurance of the care quality
 - personalised care based on individual needs i.e. avoid morning visits if customer sleeps late
 - gives additional information in alarm situations
 - Provides remote and fast information of customer's presence and activity
 - Personnel can check that the customers are alive (moving) and at home without visiting -> adds security and saves personnel time
 - Provides information on customer's behavioural patterns:
 - useful to know e.g. night time awakenings and bathroom visits -> personnel can take actions to decrease risks for falling
- ⇒ Enables the development and coordination of job routines by the care personnel

Example: Curve supports the user's complaint

manual alarm,
user complains stomach ache



poor sleep

Automatic alarms with Vivago System



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Automatic alarms based on the activity signal

- Deterioration
 - Alarm, if no movement is detected
 - Alarm delay is adaptive and depends on the normal activity cycle of the subject (30min - 3h30min)
 - Different limits for the day and night
- Passivity
 - Notification, if the average activity has been below a fixed level during the past 4 hours
 - Daytime only
- Curve alarms (institutions)
 - Alarm will be generated if the activity is constantly above (high activity) or below (low activity) a user set value (0-100%)
 - Alarm delays adjustable (3min -> whole day)
 - Different limits can be set for the day and night
- Low temperature alarm (institutions)
 - Alarm will be generated if the activity has been low for 30min and wrist temperature has dropped below 28C.



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Validation studies

- In co-operation with:
 - National Research Center of Finland (VTT, Information Technology, Tampere)
 - University of Tampere, faculty of public health
- Medical Advisor
 - Dr. Markku Partinen, Rinnekoti Research Center



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Publications

1. Automatic Sleep-Wake and Nap Analysis with a New Wrist Worn Online Activity Monitoring Device Vivago WristCare,
Lötjönen et al, **Sleep 01/2003**
 - Vivago activity signal is comparable to actigraphy in sleep-wake studies and can be used in long-term monitoring of sleep-wake patterns
2. Circadian activity rhythm in demented and non-demented nursing-home residents measured by telemetric actigraphy,
Paavilainen et al, **Journal of Sleep Research, 03/2005**
 - Vivago can be used in the screening and follow up of elderly subjects for sleep and circadian rhythm related problems, which are associated with dementia and changes in functional capacity
3. Telemetric activity monitoring as an indicator of long-term changes in health and well-being of older people, Case Study
Paavilainen et al, **Gerontechnology Journal, 10/2005**
 - Vivago can be used to monitor changes in health status and to follow up on the effects of treatment in elderly care to support nursing practises.



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IST activity monitoring is clinically validated



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- Changes in activity level and daily rhythms forecast the development of health and well being
- Activity signal generated by the Vivago system measures diversified activity level and daily rhythm
- IST method is as reliable as well-established diagnostic tools, e.g. actigraph

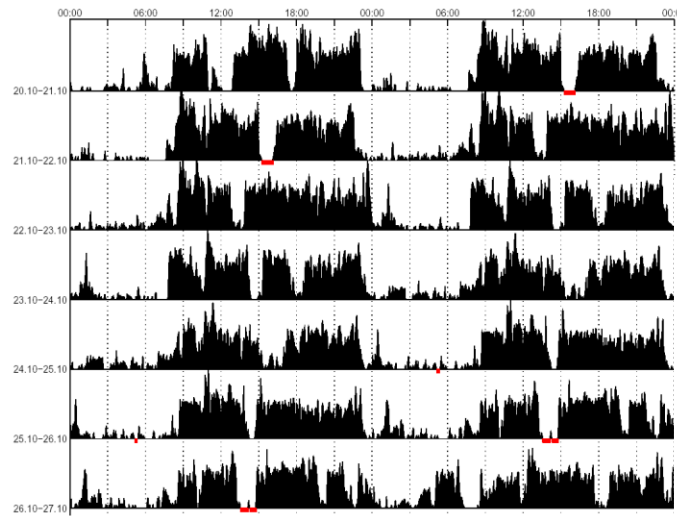


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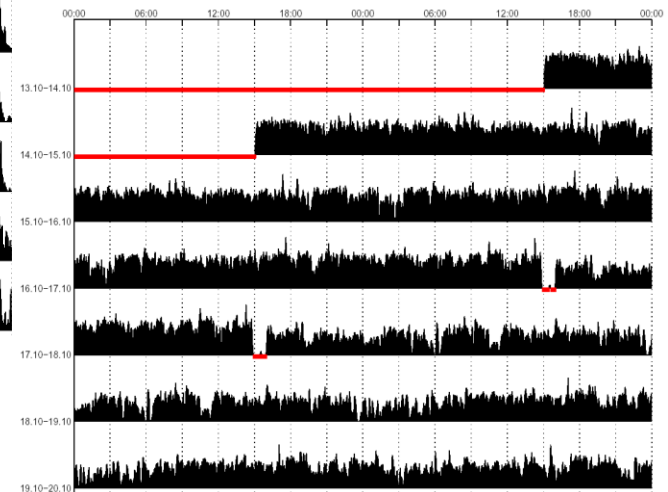
Case examples

Application in the dementia care

No dementia -> good
sleep-wake rhythm



Person with severe
dementia -> sleep-wake
rhythm disappears



Severity of
dementia increases



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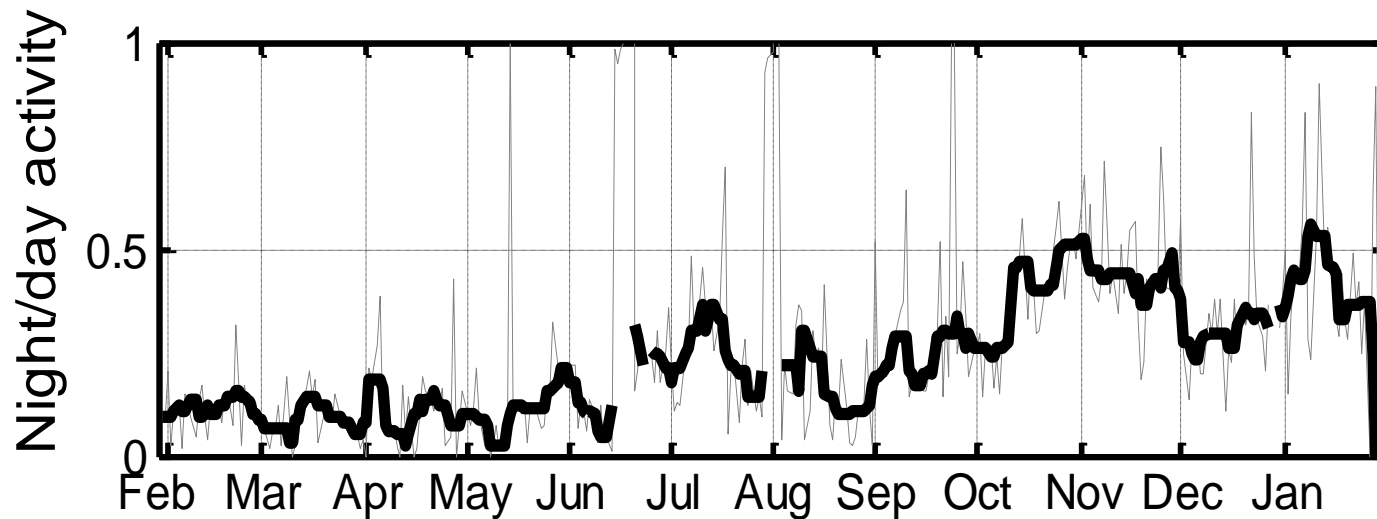
ACTIVITY CURVE CAN BE USED FOR:

- FOLLOW-UP OF CONDITION AFTER DIAGNOSIS
- EVALUATION OF PERSON'S ABILITY FOR INDEPENDENT LIVING

Monitoring is continuous and unobtrusive
in the person's normal living environment!

Case 4

- 83-year old woman
- Alzheimers disease (CDR 3, MMSE 14)
- low functional capacity (Barthel 65)
- background: falls, changes in diurnal rhythm, weakening of general condition, fatigue, increasing difficulties in eating and other daily activities
- hospitalised 28.1.2003 because of a pneumonia
- exitus 1.2.2003



Summary



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IST activity monitoring creates new requirements for a successful care



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