# Multisignal digital biosensors- digital Biosensors integrated with enzyme logic systems

Maren Krafft

Universitt Passau, Passau, Germany

**Abstract.** While common Biosensors,analytic devices to convert a biological response into a electrical signal, are based on single input, this report concentrates solely on biosensors processing multiple biochemical signals.

- biochemical logic systems
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**Keywords:** Biomolecular computing · Biosensors · enzyme logic gates · biosensing · biocomputing systems · enzyme logic circuits · biomedical applications

## 1 Introduction

- common biosensing devises are based on a single input
- high-fidelity compared
- closed loop/feedback loops possible (sense/act/treat)
- rapid and reliable assessment of overall physiological condition
- could initiate optimal timely therapeutic intervention
- application og biomolecular logic systems for analystic purposes could yield a novel class of biosensors: many input signals and binary outputs
- logically processed feedback between drug appl. and physiological conditions can signifacntly imprive drug targeting and efficiency

- Biosensors + enzymes

## 2 motivation

- high-fidelity
- rapid and reliable assessment of overall physiological condition
- optimal timely therapuetic intervention
- feedback-loops
- biomedical monitoring(example, closed-loop-¿ patient tailored timely therapy, personalized medicine= sensing devices + delivery devices)
  - closed-loop -¿ patient tailored timely therapy possible
  - sensing devices + delivery devices = personalized medicine

  - example feedback-loop: diabetes: electrochemical glucose sensing element + insulin-delivery feedback loop
  - fast delivery in emergencies
- environmental monitoring
- national defense
- food safety

# 3 concept

## 3.1 Biosensors: layers

Definition electrochemical biosensors

- immobilization of the biocomputing reagent layer
- transducer layer
- parallel or single

## 3.2 Biocomputing: concept

**allgemein**

- subarea of chemical computing
- single logic gates to small logic networks (for example half-adder/ half subtractor)
- biomolecular systems for processing chemical information
- different biomolecular tools (including proteins/enzymes) assemble biocomputing systems processing biochemical information

**what would bring it to biosensors**

- Enzyme logic system: multiassemblies to perform simple arithmetic functions
- idea: applicatoin of biomolecular logic system for analytical purpose new class of biosensors that accept many input signals and produce binary outputs in form yes/no
- example analyse protein libraties associated with muliple sclerosis(58)

**how enzme-based logic gates work** Enzyme logic gates

- enzymatic reactions
- coupling of logic gates with electronic transducers and signal responsive materials
- transducers:
- signal responive material

example theoretical with graphics

- glucose oxidase and catalyse operating as logic gates:
- input : H2O2 and glucose
- gluconic acid = biocalatyltic oxidation of glucose
- only when both present opical output signal. = AND
- define logic values: small changes = 0 and large absorbance changes as 1 =¿ AND
- similar possible with XOR,AND, OR, NOR, INHIBIT
- with logic gates with modular structur that enables therir assembly in networks NAND/ NOR possible
- logic gates and their networks = biomolecular information processing systems
- =¿ biosensoric systems with logically processed signals represented by various biomarkers(characteristic of different abnormal physiological conditions)

example ph

- pH changes in solution as logic respones to input signals
- AND invertase + glucose oxidase (from 5.8 to 3.5)
- OR ersterase and glucose oxidase in glucose and ethyl butyrate - when one of both present -¿acidification
- neutral ph = 3,5

Conclusion:

- don't solve real computing problem nor operate as useful biosensors
- represent first step toward the development of digital biosensors
- funfact optimization of enzymatic reaction, up to 10 logic gates concatenated with low noise in the system

#### for biochemical analytic applications

- design of biosensoric systems with logically processes signals represented by varous biomarkers characteristic for different abnormal physiological conditions

### 3.3 Biosensors with Biocomputing = biochemical logic systems

Biosensors logically processing multiple biochemical signals
-such procassed information produces a final output yes/no
- boolean logic networks composed of biomolecular systems

- multiple target analytes(inputs) for enzyme gates
- high-fidelity compared
- closed loop/feedback loops possible (sense/act/treat)
- rapid and reliable assessment of overall physiological condition
- could initiate optimal timely therapeutic intervention

- biosensors + enzyme logic gates
- allows direct coupling of signal processing with chemical actuators
- application og biomolecular logic systems for analystic purposes could yield a novel class of biosensors: many input signals and binary outputs
- logically processed feedback between drug appl. and physiological conditions can signifacntly imprive drug targeting and efficiency
- difficulties: complexity by assembling individual logic gates into complex logic networks (intelligent by molecular logic) (43-34-67)
- new approach for the sensor design and operation, interfach biocomputing system and electronic transducers

# 4 possible application

- not just chronic but also ..........
- state of the art
- feedback loop currently devoted to management of diabetes through integration of an electrochemical glucose sensing element with an insulin-delivery feedback loop for the optimal dose of insulin (69-71)
- example analyse protein libraties associated with muliple sclerosis(58) ENzyme logic system recognizing various injury-related physiological conditions
  - types of injuries result in concentrations of chemical substances in the body

  - example: lactate axidase, horeserasish peroxidase and glucose dehydrogenase = designed to process biochemical information related to pathophysiological conditions from brain injury
  - markers: glucose(hemorrhagic shock),lactate(rhagic shock or traumic brain injury) and norepinephrine(traumatic injury)
  - logic 0 = normal concentrations
  - change results into different numbers 1,2,3 - convenient
  - = biocomputing logic system
  - challenge: difference between normal and unnormal minimal =¿ not linear, should be sigmoidal

# 5 considerations

## 5.1 surface immobilization of the biocomputing machinery

- optimal surface confinement of the biocomputing layer
- engineering enzyme microenvironment (transducer layer)
- contact between biocomputing layer and transducing surface
- combine individual logic-gates and maintain high enzymatic stability and reataining individual reagents
- leakage of cosubstrate

- no cross-reactions
- surface confinement? layer-by layer? more efficient and rational
- level of the surface confined reagents tailored for account of different input concentrations /enzyme activities
- coating: optimized for transport and excluding potential interfernece and protecting the surface

### 5.2 optimal transduction of biocomputing signal processes

- simultaneous measurements of multiple outputs require different transduction strategies (common: fixed potential )

- Requires:interface of biocomputing systems + electronic transducer Therefore
- scalability (increasing nuber of logic gates, assembling into complex networks)
- complexity(coupling of gates abd non boolean elements)
- composition, preparation and immobilization of the biocomputing surface layer
- layer by layer
- optimal surface confinement
- careful engineering of the enzyme microenvironment(on transducer surface) for performance
- biocomputing layer + transducing layer + combine individual logic-gate elements

## 6 Conclusion

good but needs lot of work
sums up bla

## References

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