Su	rname:	First Name:	Matriculation number	er:
Su	bject: Prog	ramme: Bachelor Master	Lehramt others Sign	nature:
	Please fill in your name above	and tick exactly ONE box for the	e right answer of each question b	elow.
1.	the phone breaks when it is dro experiment we have dropped 10	opped. We assume that the phone	e thrown onto the ground either broken smartphones. What is the	v the unknown probability $\theta$ that breaks or has no damage. In an negative log likelihood function
	(a) $x - 42 \log \theta - 58 \log(1 - 2 \log \theta)$	- θ)	(b)	$(1-\theta)$
	(c)	$\overline{\theta}$ )	(d) $\log(58\theta) + \log(42(1 - \theta))$	- θ))
2.		ch is by nature a NON-LINEAR ich of the following algorithms c		$y(t) = \theta_1 \cos(\theta_2 t + \theta_3)$ , where ameters $\theta$ ?
	(a) X Maximum a Posteriori	Estimation (MAP)	(b) Recursive Least Square	res (RLS)
	(c) Weighted Least Squar	es (WLS)	(d) Linear Least Squares	(LLS)
3. Suppose now that the system given in the previous question can be . Which of the following algorithms could you use to estimate the problems or high computational costs for a coninuous and infinit		ne parameters $\theta$ of this linear mod		
	(a) LLS	(b) MAP	(c) X RLS	(d) WLS
4.	question $\Sigma_{\hat{\theta}}$ . The model is given		$Q_N \sim \mathcal{N}(0, \Sigma_\epsilon), Q_N = \Phi_N^ op \Phi_N  \mathrm{d} t$	imate computed in the previous and $L(\theta,y_N)$ is the negative log
	(a) $\square$ $\nabla^2_{\theta} L(\theta, y_N)$	(b) $\square \Phi_N^+ \Sigma_{\epsilon_N} \Phi_N^+^\top$	(c) $\mathbf{x}$ $Q_N^{-1}$	$(d) \ \boxed{ \ } (\Phi_N^\top \Sigma_{\epsilon_N}^{-1} \Phi_N)^{-1}$
5.		$y_N = [y(1), y(2), \dots, y(N)]^T,$		unknown parameter $\theta$ , and a set problem you need to solve for a
	(a) $\ y(k) - \theta e^{-\theta}\ _2^2$		(b) $\mathbf{x} - N\log(\theta) + \theta \sum_{k=1}^{N}$	y(k)
	$\boxed{ (c)  \boxed{ \ \theta e^{-\theta y(k)}\ _2^2} }$			
6.		s question, what is a lower bound sher information matrix is define	•	(0)
	(a) $\square$ $N/\theta^2$		(b)	$\sum_{k} y_{k} ] \mathrm{d} y_{N} \big)^{-1}$
	(c) $\mathbf{x}$ $\theta_0^2/N$		(d)	$\sum_{k} y_{k} ] \mathrm{d} y_{N}$
7.	Suppose you are given the Fish matrix $\Sigma_{\hat{\theta}}$ of your estimate $\hat{\theta}$ ? $\Sigma_{\hat{\theta}} \succeq M^{-1}$	her information matrix $M$ of the	corresponding problem, what is	the relation with the covariance

9.	Given a set of measurements $y_N$ which of the following minimis $\hat{\theta}(N+1)$ after $N+1$ measurements	sation problems is solved at eac	h iteratio			
	$(a) \boxed{\mathbf{x}} \ y_{N+1} - \Phi_{N+1} \cdot \theta\ _2^2$		(b) [	(b)		
		$N) - \varphi(N)^{T} \theta \ _2^2$	(d)	$   y_N - \Phi_N \cdot \theta  _{Q_N}^2 $		
10.	In $L_2$ estimation the measurement compared to $L_1$ estimation.	ent errors are assumed to follow	a dist	ribution and it is genera	lly speaking more to outliers	
	(a) Laplace, sensitive	(b) Laplace, robust	(c) [	Gaussian, robust	(d) X Gaussian, sensitive	
11.	The PDF of a random variable $x$ ments, $y(1) = 3$ , $y(2) = 6$ , and	Y is given by $p(y) = \frac{1}{2\sqrt{2\pi}} \exp(y(3)) = 12$ . What is the minimiz	$(-\frac{1}{2}\frac{\ y-\theta\ }{4})$ er $\theta^*$ of t	$\frac{\parallel_2^2}{2}$ ), with unknown $\theta \in$ he negative log-likeliho	$\mathbb{R}$ . We obtained three measure-od function ?	
	(a) x 7	(b) <u>6</u>	(c)	9	(d) <u>4</u>	
12.	Please give the ODE of a linear $Ax + Bu$	time invariant (LTI) system, with	n state ve	ctor $x$ and input vector $x$	$u.\ \dot{x}=\dots$	
13.	Please identify the most general $n = \max(n_a, n_b)$ . $G(z) = \dots$	ll transfer function that still is a	Auto R	egressive Model with E	Exogenous Inputs (ARX) where	
	(a)	(b)	(c) <b>X</b>	$ \frac{b_0 z^n + b_1 z^{n-1} + \dots + b_n}{a_0 z^n + a_1 z^{n-1} + \dots + a_n} $	(d)	
14.	Identify most general transfer fu	nction that still is a Finite Impul	se Respo	onse (FIR) model with $n$	$= \max(n_a, n_b). G(z) = \dots$	
	(a) $\frac{b_0 z^n + b_1 z^{n-1} + \dots + b_n}{a_0 z^n + a_1 z^{n-1} + \dots + a_n}$	(b)	(c)	$\frac{z^n}{a_0z^n + a_1z^{n-1} + \dots + a_n}$	(d) $\left[ \begin{array}{c} \mathbf{X} \end{array} \right] \xrightarrow{b_0 z^n + b_1 z^{n-1} + \ldots + b_n}$	
15.	Which of the following model e	quations describes a FIR system	with inp	ut $u$ and output $y$ ? $y(k - y)$	+1) =	
	(a) $\square u(k+1) + y(k)$	(b) $\square u(k) \cdot y(k)$	(c) [	$u(k) + \sin(k \cdot \pi)$		
16.	Which of the following dynamic	$\underline{\underline{\underline{u}}}$ models with inputs $u(t)$ and ou	tputs $y(t)$	) is <b>NEITHER</b> linear <b>N</b>	IOR affine.	
	(a) $\lim \dot{y}(t) + \sin(t) = u(t)$	(b) $\square \dot{y}(t) = u(t) + t$	(c) <b>x</b>	$\dot{y}(t) = \sqrt{t \cdot u(t)}$		
17.	Which of the following models	with input $u(k)$ and output $y(k)$	is <b>NOT</b>	inear-in-the-parameters	w.r.t. $\theta \in \mathbb{R}^2$ ?	
	(a) $\square y(k) = \theta_1 u(k)^2 + \theta_2 e$	xp(u(k))	(b)			
	(c) $y(k) = y(k-1) \cdot (\theta_1)$	$+ \theta_2 u(k))$				
18.	Which of the following models	is time invariant?				
	(a) $\ddot{y}(t)^2 = u(t)^t + e^{u(t)}$	(b)	(c) <b>x</b>	$\dot{y}(t) = \sqrt{u(t)}$		
19.	By which of the following form	ulas is the joint distribution for I	V indepe	ndent measurements $y_N$	$e \in \mathbb{R}^N$ given? $p(y_N \theta) = \dots$	
	(a) $\prod \int_{y_N} p(y \theta) \ dy$	(b)	(c) <u>x</u>	$\prod_{i=0}^{N} p(y(i) \theta)$	(d) $\prod \sum_{i=0}^{N} p(y(i) \theta)$	
20.	Which of the following statemen	nts about Maximum A Posteriori	(MAP)	estimation is not true		
	(a) $\widehat{\theta}_{MAP} = \arg\min_{\theta \in \mathbb{R}} [-$	$-\log(p(y_N \theta)) - \log(p(\theta))]$	(b) <b>x</b>	MAP assumes a linear	model	
	(c) MAP is a generalization	on of ML	(d) [	MAP requires a-priori	knowledge on $\theta$	

8. Give the name of the theorem that provides us with the above result. Cramer-Rao Inequality

Prof. Dr. Moritz Diehl, IMTEK, Universität Freiburg January 13, 2017, 10:15-11:45, Freiburg

Su	rname:	First N	lame:		Matriculation number:		er:
Su	bject: Progr	ramme:	Bachelor	Master	Lehramt	others Sig	nature:
	Please fill in your name above a	and tick	exactly ONE	box for the	e right answ	ver of each question b	pelow.
1.		$y_N = [y]$	$y(1), y(2), \ldots$	$[y(N)]^T$			unknown parameter $\theta$ , and a set problem you need to solve for a
	(a) $\ \theta e^{-\theta y(k)}\ _2^2$				(b) <b>x</b> -	$-N\log(\theta) + \theta \sum_{k=1}^{N}$	y(k)
	(c) $\ y(k) - \theta e^{-\theta}\ _2^2$				(d)	$-\log\sum_{k=1}^{N}\theta e^{-\theta y(k)}$	
2.	For the problem in the previous that $\theta_0$ is the true value? The Fig.				ed as $M = $	$\int_{yN} \nabla_{\theta}^2 L(\theta_0, y_N) \cdot p$	
	(a) $\mathbb{X}$ $\theta_0^2/N$				(b) [	$\int_{y_N} N\theta^{N-2} \exp[-\theta$	$\theta \sum_{k} y_{k} ] \mathrm{d} y_{N} \Big)^{-1}$
	(c) $\square N/\theta^2$				(d)	$\int_{y_N} N\theta_0^{N-2} \exp[-\theta \sum_{i=1}^{N} \theta_i^{N-2}] \exp[-\theta \sum_{i$	$\sum_{k} y_{k} ] \mathrm{d} y_{N}$
3.	You are given a pendulum which $y(t)$ are the measurements. While						$y(t) = \theta_1 \cos(\theta_2 t + \theta_3)$ , where rameters $\theta$ ?
	(a) X Maximum a Posteriori	Estimati	on (MAP)		(b) [ I	Linear Least Squares	(LLS)
	(c) Recursive Least Squar	es (RLS)	)		(d) \[ \] \[ \]	Weighted Least Squar	res (WLS)
4.		hms coul	ld you use to	estimate th	ne paramete	rs $\theta$ of this linear mo	t is linear in the parameters (LIP) del without running into memory
	(a) MAP	(b) <u>x</u>	RLS		(c) [ I	LLS	(d) WLS
5.		en as $y_N$	$\Phi = \Phi_N \theta + 1$	$\epsilon_N$ with $\epsilon_N$	$_{V}\sim\mathcal{N}(0,\Sigma)$	$(\Sigma_{\epsilon}), Q_N = \Phi_N^{\top} \Phi_N$	timate computed in the previous and $L(\theta, y_N)$ is the negative log
	(a) $\mathbf{X}$ $Q_N^{-1}$		$]\Phi_N^+\Sigma_{\epsilon_N}\Phi_N^+$			$\nabla_{\theta}^2 L(\theta, y_N)$	
6.	The PDF of a random variable $Y$ is given by $p(y) = \frac{1}{2\sqrt{2\pi}} \exp(-\frac{1}{2} \frac{\ y-\theta\ _2^2}{4})$ , with unknown $\theta \in \mathbb{R}$ . We obtained three measure ments, $y(1) = 3$ , $y(2) = 6$ , and $y(3) = 12$ . What is the minimizer $\theta^*$ of the negative log-likelihood function?				$\mathbb{R}$ . We obtained three measure- ood function ?		
	(a) 4	(b) [	6		(c) 9	1	(d) <b>x</b> 7
7.	Suppose you are given the Fish matrix $\Sigma_{\hat{\theta}}$ of your estimate $\hat{\theta}$ ? $\Sigma_{\hat{\theta}} \succeq M^{-1}$	er inforn	nation matrix	M of the	correspond	ling problem, what is	s the relation with the covariance
8.	Give the name of the theorem the Cramer-Rao Inequality	at provi	des us with th	ne above re	sult.		

12

9.	Which of the following models i	s time invariant?			
	(a)	(b)	(c)	(d) $\mathbf{x}$ $\dot{y}(t) = \sqrt{u(t)}$	
10.	By which of the following form	alas is the joint distribution for A	$V$ independent measurements $y_N$	$\in \mathbb{R}^N$ given? $p(y_N \theta) = \dots$	
	(a) $\prod_{i=0}^{N} p(y(i) \theta)$	(b)	(c) $\prod \sum_{i=0}^{N} p(y(i) \theta)$	(d) $\prod \int_{y_N} p(y \theta) dy$	
11.	Which of the following statemer	nts about Maximum A Posteriori	(MAP) estimation is not true		
	(a) MAP is a generalization	n of ML	(b) X MAP assumes a linear model		
	(c) $\widehat{\theta}_{MAP} = \arg\min_{\theta \in \mathbb{R}} [-$	$-\log(p(y_N \theta)) - \log(p(\theta))]$	(d) MAP requires a-priori	knowledge on $\theta$	
12. Which of the following model equations describes a FIR system with input $u$ and output $y$ ? $y(k+1) = \dots$					
	(a) $\mathbf{x}$ $u(k) - 5 \cdot u(k-1)$	(b) $u(k+1) + y(k)$	(c) $u(k) \cdot y(k)$	(d) $u(k) + \sin(k \cdot \pi)$	
13. Which of the following dynamic models with inputs $u(t)$ and outputs $y(t)$ is <b>NEITHER</b> linear <b>N</b>		OR affine.			
	(a) $\mathbf{x}\dot{y}(t) = \sqrt{t \cdot u(t)}$	(b)	(c) $\Box t\dot{y}(t) = u(t) + 2$	(d)	
	Given a set of measurements $y_N$ which of the following minimis $\hat{\theta}(N+1)$ after $N+1$ measuren	ation problems is solved at each	h iteration step of the RLS algo		
	$(a) \boxed{\mathbf{x}} \ y_{N+1} - \Phi_{N+1} \cdot \theta\ _2^2$		(b) $\ y_N - \Phi_N \cdot \theta\ _{Q_N}^2$		
		$(N) - \varphi(N)^{\top}\theta\ _2^2$	(d) $\ \theta - \hat{\theta}(N)\ _2^2 + \ y(N+1) - \varphi(N+1)^{\top}\theta\ _2^2$		
	Please identify the most genera $n = \max(n_a, n_b)$ . $G(z) = \dots$	l transfer function that still is a	Auto Regressive Model with E	Exogenous Inputs (ARX) where	
	(a)	(b)	(c) $\left[ \frac{b_0 z^n + b_1 z^{n-1} + \dots + b_n}{a_0 z^n + a_1 z^{n-1} + \dots + a_n} \right]$	$(d) \qquad \frac{b_0 z^n + b_1 z^{n-1} + \ldots + b_n}{a_0 z^n}$	
	We want to assess the robustness the phone breaks when it is drop experiment we have dropped $1000$ $f(\theta)$ that we need to minimize in	pped. We assume that the phone of smartphones and obtained 42 b	e thrown onto the ground either broken smartphones. What is the	breaks or has no damage. In an	
	(a) $\square$ 58 log $\theta$ + 42 log(1 - $\theta$	)	(b)	$(1-\theta)$	
	(c) $x - 42 \log \theta - 58 \log(1 - 2 \log \theta)$	- θ)	(d) $\log(58\theta) + \log(42(1 - \theta))$	- θ))	
	Please give the ODE of a linear $Ax + Bu$				
18.			is <b>NOT</b> linear-in-the-parameters w.r.t. $\theta \in \mathbb{R}^2$ ?		
	(a) $\mathbf{x}$ $y(k) = \theta_1 \exp(\theta_2 u(k))$		(b) $\square y(k) = y(k-1) \cdot (\theta_1 + \theta_2 u(k))$		
	(c) $\square y(k) = \theta_1 u(k)^2 + \theta_2 \epsilon$	$\exp(u(k))$	(d) $\square y(k) = \theta_1 \sqrt{u(k)} + \theta_2 u(k)$		
	In $L_2$ estimation the measurement errors are assumed to follow compared to $L_1$ estimation.		a distribution and it is genera	lly speaking more to outliers	
	(a) X Gaussian, sensitive	(b) Gaussian, robust	(c) Laplace, sensitive	(d) Laplace, robust	
20.	Identify most general transfer fu	nction that still is a Finite Impul	se Response (FIR) model with $n$	$= \max(n_a, n_b). G(z) = \dots$	
	(a) $\frac{b_0 z^n + b_1 z^{n-1} + \dots + b_n}{a_0 z^n + a_1 z^{n-1} + \dots + a_n}$	(b) $\left[\mathbf{X}\right] \frac{b_0 z^n + b_1 z^{n-1} + \dots + b_n}{a_0 z^n}$	(c) $ \frac{z^n}{a_0 z^n + a_1 z^{n-1} + \dots + a_n} $	(d)	

13

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St	ırname:	First Name:		Matriculation number:			
St	ıbject:	Programme: Bachelor	Master	Lehramt	others Sign	nature:	
	Please fill in your name ab	ove and tick exactly C	NE box for the	e right answ	er of each question be	elow.	
1.	1. Suppose you are given the Fisher information matrix $M$ of the corresponding problem, what is the relation with the covariance matrix $\Sigma_{\hat{\theta}}$ of your estimate $\hat{\theta}$ ? $\Sigma_{\hat{\theta}} \succeq M^{-1}$						
2.	Give the name of the theor Cramer-Rao Inequality	em that provides us wi	th the above re	esult.			
3.	Please identify the most $g$ $n = \max(n_a, n_b)$ . $G(z) = \max(n_a, n_b)$		n that still is	a Auto Reg	ressive Model with I	Exogenous Inputs (ARX) where	
	(a)	$\begin{array}{c c} \hline \\ \hline $	$\frac{z^{n-1} + \ldots + b_n}{z^{n-1} + \ldots + a_n}$	$(c) \qquad \overline{z}$	$\frac{b_0 z^n}{n + a_1 z^{n-1} + \ldots + a_n}$	(d)	
4.	Which of the following mo	del equations describe	s a FIR system	with input	u and output $y$ ? $y(k - y)$	$(+1) = \dots$	
	(a) $\mathbf{x}$ $u(k) - 5 \cdot u(k-1)$	) (b) $\square u(k) \cdot y$	y(k)	(c) u	$e(k) + \sin(k \cdot \pi)$	$(d) \qquad u(k+1) + y(k)$	
5.	In $L_2$ estimation the measured to $L_1$ estimation		med to follow	a distrib	oution and it is genera	lly speaking more to outliers	
	(a) Laplace, robust	(b) Laplace	e, sensitive	(c) (C)	Gaussian, robust	(d) X Gaussian, sensitive	
6.	Identify most general trans	fer function that still is	a Finite Impu	lse Respons	e (FIR) model with n	$a = \max(n_a, n_b). G(z) = \dots$	
	(a)	$(b) \boxed{\mathbf{x}} \frac{b_0 z^n + b_1}{a}$	$\frac{z^{n-1} + \ldots + b_n}{a_0 z^n}$	$(c) \qquad \frac{b}{a}$	$a_0 z^n + b_1 z^{n-1} + \dots + b_n \\ a_0 z^n + a_1 z^{n-1} + \dots + a_n$	(d)	
7.	the phone breaks when it is	s dropped. We assumed 100 smartphones an	e that the phon d obtained 42	ne thrown on broken sma	nto the ground either	v the unknown probability $\theta$ that breaks or has no damage. In an negative log likelihood function	
	(a) $\log(58\theta) + \log(48\theta)$	$2(1-\theta))$		(b) 5	$8\log\theta + 42\log(1 -$	$\theta$ )	
	$ (c) \boxed{\mathbf{x}} -42\log\theta - 58\log\theta $	$g(1-\theta)$		(d)	$-\log(42\theta) - \log(58($	$(1-\theta)$	
8.	Given a set of measurement which of the following min $\hat{\theta}(N+1)$ after $N+1$ means	nimisation problems i	s solved at each	ch iteration	model $y_N = \Phi \theta$ , when step of the RLS algorithm	$\mathbf{re} \ \Phi = [\varphi(1), \varphi(2), \dots, \varphi(N)]^T,$ writhm to estimate the parameter	
	(a) $\ \theta - \hat{\theta}(N)\ _2^2 + \ $	$y(N+1) - \varphi(N+1)$	$\  \theta \ _2^2$	(b) <b>x</b>	$y_{N+1} - \Phi_{N+1} \cdot \theta \ _2^2$		
	(c) $\ \theta - \hat{\theta}(N)\ _{Q_N}^2$			II "	$y_N - \Phi_N \cdot \theta \ _{Q_N}^2$		
9.	The PDF of a random variments, $y(1) = 3$ , $y(2) = 6$	able Y is given by $p(y)$ , and $y(3) = 12$ . What	$=\frac{1}{2\sqrt{2\pi}}\exp$ is the minimiz	$(-rac{1}{2}rac{\ y- heta\ _2^2}{4}$ zer $ heta^*$ of the	), with unknown $\theta \in$ negative log-likeliho	$\mathbb{R}$ . We obtained three measure-od function ?	
	(a) 9	(b) 6		(c) 4		(d) x 7	

10.	Please give the ODE of a linear time invariant (LTI) system, with state vector $x$ and input vector $u$ . $\dot{x} = \dots Ax + Bu$				
		$y_N = [y(1), y(2), \dots, y(N)]^T,$	oution, $p_X(x) = \theta e^{-\theta x}$ , with an what is the right minimisation p		
	$a) \qquad \ \theta e^{-\theta y(k)}\ _2^2$		(b) $\mathbf{x} - N\log(\theta) + \theta \sum_{k=1}^{N}$	y(k)	
			(d) $  y(k) - \theta e^{-\theta}  _2^2$		
12.	For the problem in the previous that $\theta_0$ is the true value? The Fig.	question, what is a lower bound sher information matrix is define	d on the covariance for any unbited as $M = \int_{yN} \nabla^2_{\theta} L(\theta_0, y_N) \cdot p(0)$	ased estimator $\hat{\theta}(y_N)$ , assuming $y_N \theta_0)\mathrm{d}y_N$ .	
	(a) $\prod \int_{y_N} N\theta_0^{N-2} \exp[-\theta \sum$	$\sum_k y_k] \mathrm{d} y_N$	(b) $\prod \left( \int_{y_N} N\theta^{N-2} \exp[-\theta] \right)$	$\sum_{k} y_{k} ] \mathrm{d} y_{N} \big)^{-1}$	
	(c) $\square N/\theta^2$		(d) $\mathbf{x}$ $\theta_0^2/N$		
13.	Which of the following dynamic	u models with inputs $u(t)$ and ou	tputs $y(t)$ is <b>NEITHER</b> linear <b>N</b>	IOR affine.	
	(a) $\lim \dot{y}(t) + \sin(t) = u(t)$	(b)	(c) $\mathbf{x}\dot{y}(t) = \sqrt{t \cdot u(t)}$	$d) \qquad t\dot{y}(t) = u(t) + 2$	
14.			system and can be modeled by ould you use to estimate the para		
	(a) X Maximum a Posteriori	Estimation (MAP)	(b) Weighted Least Squares (WLS)		
	(c) Linear Least Squares (	(LLS)	(d) Recursive Least Squares (RLS)		
15.	. Which of the following algorit		be approximated by a model that is linear in the parameters (LIP) e parameters $\theta$ of this linear model without running into memory the flow of measurement data?		
	(a) LLS	(b) MAP	(c) WLS	(d) X RLS	
	question $\Sigma_{\hat{\theta}}$ . The model is give	•	on of the covariance of the esting $V \sim \mathcal{N}(0, \Sigma_{\epsilon}), \ Q_N = \Phi_N^{\top} \Phi_N \ \text{and} \ \text{by } \Sigma_{\hat{\theta}} \approx \dots$		
	(a) $\mathbf{X}$ $Q_N^{-1}$	(b) $\square \nabla^2_{\theta} L(\theta, y_N)$	(c) $\square \Phi_N^+ \Sigma_{\epsilon_N} \Phi_N^+^\top$	$(d) \ \square \ (\Phi_N^\top \Sigma_{\epsilon_N}^{-1} \Phi_N)^{-1}$	
17.	Which of the following models	is time invariant?			
	(a) $ \ddot{y}(t)^2 = u(t)^t + e^{u(t)} $	(b)	(c) $\prod t \cdot \ddot{y}(t) = u(t)^3$	(d) $\mathbf{x}$ $\dot{y}(t) = \sqrt{u(t)}$	
18.	By which of the following form	ulas is the joint distribution for I	N independent measurements $y_N$	$e \in \mathbb{R}^N$ given? $p(y_N \theta) = \dots$	
	(a) $\sum_{i=0}^{N} p(y(i) \theta)$	(b)	(c) $\prod \int_{y_N} p(y \theta) \ dy$	(d) $\prod_{i=0}^{N} p(y(i) \theta)$	
19.	Which of the following statemen	nts about Maximum A Posteriori	i (MAP) estimation is not true		
	(a) $\widehat{\theta}_{MAP} = \arg\min_{\theta \in \mathbb{R}} [-$	$-\log(p(y_N \theta)) - \log(p(\theta))]$	(b) $\square$ MAP requires a-priori knowledge on $\theta$		
	(c) X MAP assumes a linear	model	(d) MAP is a generalization	on of ML	
20. Which of the following models with input $u(k)$ and output $y(k)$ is <b>NOT</b> linear-in-the-par			is <b>NOT</b> linear-in-the-parameters	w.r.t. $\theta \in \mathbb{R}^2$ ?	
	(a) $\sum y(k) = y(k-1) \cdot (\theta_1 \cdot \theta_2)$	$+ \theta_2 u(k)$	(b) $\square y(k) = \theta_1 u(k)^2 + \theta_2 \epsilon$	$\exp(u(k))$	
	$ (c)  y(k) = \theta_1 \sqrt{u(k)} + \theta_2 $	u(k)	(d) $\mathbf{x}$ $y(k) = \theta_1 \exp(\theta_2 u(k))$	)	

Ç.,	rname:	First Name:	Matriculation numbe	<b></b> .		
Su	mame.	riist Name.	Matriculation numbe	1.		
Su	bject: Progr	ramme: Bachelor Master	Lehramt others Sign	ature:		
1	Please fill in your name above and tick exactly ONE box for the right answer of each question below.  1. Which of the following models is time invariant?					
1.	(a) $\ddot{y}(t)^2 = u(t)^t + e^{u(t)}$		(c) $\dot{\mathbf{x}} \dot{y}(t) = \sqrt{u(t)}$	(d) $t \cdot \ddot{y}(t) = u(t)^3$		
2.			$V$ independent measurements $y_N$			
	(a) $\prod_{i=0}^{N} p(y(i) \theta)$	(b) $\prod \int_{y_N} p(y \theta) \ dy$	(c) $\prod \sum_{i=0}^{N} p(y(i) \theta)$	(d)		
3.	Which of the following statement	nts about Maximum A Posteriori	(MAP) estimation is not true			
	(a) MAP is a generalizatio	n of ML	(b) MAP requires a-priori	knowledge on $\theta$		
	(c) X MAP assumes a linear	model	(d)	$-\log(p(y_N \theta)) - \log(p(\theta))]$		
4.			system and can be modeled by ould you use to estimate the para			
	(a) Weighted Least Squares (WLS)		(b) X Maximum a Posteriori Estimation (MAP)			
	(c) Linear Least Squares (	(LLS)	(d) Recursive Least Square	es (RLS)		
5.	. Which of the following algorit		be approximated by a model that e parameters $\theta$ of this linear mode te flow of measurement data?			
	(a) WLS	(b) MAP	(c) LLS	(d) X RLS		
6.	question $\Sigma_{\hat{\theta}}$ . The model is give		on of the covariance of the esting $\sim \mathcal{N}(0,\Sigma_{\epsilon}),Q_N=\Phi_N^{\top}\Phi_N$ a by $\Sigma_{\hat{\theta}} \approx \dots$			
	(a) $\mathbf{x}$ $Q_N^{-1}$	(b) $\square \Phi_N^+ \Sigma_{\epsilon_N} {\Phi_N^+}^\top$	(c) $\square (\Phi_N^\top \Sigma_{\epsilon_N}^{-1} \Phi_N)^{-1}$	(d) $\square \nabla^2_{\theta} L(\theta, y_N)$		
7.	the phone breaks when it is dro experiment we have dropped 10	pped. We assume that the phone	nd hence, we would like to know thrown onto the ground either broken smartphones. What is the ate of $\theta$ ?	breaks or has no damage. In an		
	(a) $\log(58\theta) + \log(42(1 - \theta))$	- θ))	(b) $x - 42 \log \theta - 58 \log(1 - 2 \log \theta)$	- θ)		
	(c)	$(1-\theta)$	(d)	$\theta$ )		
8.	which of the following minimis	$= [y(1), y(2), \dots, y(N)]^T \text{ from sation problems is solved at each ments? } \hat{\theta}(N+1) = \arg\min_{\theta} \frac{1}{2} \left(.\right)$	the linear model $y_N = \Phi \theta$ , when h iteration step of the RLS algo)	$\Phi = [\varphi(1), \varphi(2), \dots, \varphi(N)]^T,$ rithm to estimate the parameter		
	(a) $  y_N - \Phi_N \cdot \theta  _{Q_N}^2$		(b) $\ \theta - \hat{\theta}(N)\ _{Q_N}^2 + \ y(x)\ _{Q_N}^2$	$N) - \varphi(N)^{\top}\theta\ _2^2$		
	$(c)   \theta - \hat{\theta}(N) ^2 + \ y(N)\ ^2$	$+1) - (\rho(N+1)^{\top}\theta) _{2}^{2}$	(d) $\  u_{N+1} - \Phi_{N+1} \cdot \theta \ _2^2$			

9.	Which of the following dynamic	c models with inputs $u(t)$ and ou	tputs $y(t)$ is <b>NEITHER</b> linear <b>N</b>	IOR affine.		
	(a) $\Box \dot{y}(t) + \sin(t) = u(t)$	(b)	(c) $\prod \dot{y}(t) = u(t) + t$	(d) $\mathbf{x}\dot{y}(t) = \sqrt{t \cdot u(t)}$		
10.	Which of the following models	with input $u(k)$ and output $y(k)$	is <b>NOT</b> linear-in-the-parameters	w.r.t. $\theta \in \mathbb{R}^2$ ?		
	(a) $\square y(k) = \theta_1 u(k)^2 + \theta_2 e$	xp(u(k))	$ b)  y(k) = y(k-1) \cdot (\theta_1) $	(b)		
	(c) $y(k) = \theta_1 \sqrt{u(k)} + \theta_2$	u(k)	(d) $\mathbf{x}$ $y(k) = \theta_1 \exp(\theta_2 u(k))$	)		
11.	Which of the following model e	quations describes a FIR system	with input $u$ and output $y$ ? $y(k)$	$+1)=\dots$		
	(a) $\mathbf{x}$ $u(k) - 5 \cdot u(k-1)$	(b) $u(k) + \sin(k \cdot \pi)$	(c) $\square u(k) \cdot y(k)$			
	Suppose you are given the Fish matrix $\Sigma_{\hat{\theta}}$ of your estimate $\hat{\theta}$ ? $\Sigma_{\hat{\theta}} \succeq M^{-1}$	er information matrix $M$ of the	corresponding problem, what is	the relation with the covariance		
13.	Give the name of the theorem the Cramer-Rao Inequality	at provides us with the above re	sult.			
14.	Identify most general transfer fu	unction that still is a Finite Impul	lse Response (FIR) model with n	$= \max(n_a, n_b). G(z) = \dots$		
	(a)	(b) $ \frac{b_0 z^n + b_1 z^{n-1} + \dots + b_n}{a_0 z^n + a_1 z^{n-1} + \dots + a_n} $	(c)	(d) $\left[\begin{array}{c} \mathbf{X} \end{array}\right] \begin{array}{c} \frac{b_0 z^n + b_1 z^{n-1} + \dots + b_n}{a_0 z^n}$		
15.	Please give the ODE of a linear $Ax + Bu$	time invariant (LTI) system, with	h state vector $x$ and input vector	$u.\ \dot{x}=\dots$		
16.	In $L_2$ estimation the measurement compared to $L_1$ estimation.	ent errors are assumed to follow	a distribution and it is genera	lly speaking more to outliers		
	(a) Laplace, sensitive	(b) <b>x</b> Gaussian, sensitive	(c) Gaussian, robust	(d) Laplace, robust		
17.	Please identify the most general $n = \max(n_a, n_b)$ . $G(z) = \dots$	al transfer function that still is a	a Auto Regressive Model with I	Exogenous Inputs (ARX) where		
	(a) $\left[ \frac{b_0 z^n + b_1 z^{n-1} + \dots + b_n}{a_0 z^n + a_1 z^{n-1} + \dots + a_n} \right]$	(b)	$(c) \qquad \frac{{}_{b_0}z^n}{z^n + a_1z^{n-1} + \dots + a_n}$	$(d) \qquad \frac{b_0 z^n + b_1 z^{n-1} + \dots + b_n}{a_0 z^n}$		
18. Given the probability density function of the exponential distribution, $p_X(x) = \theta e^{-\theta x}$ , with an unknown parameter $\theta$ , as of independent measurements $y_N = [y(1), y(2), \dots, y(N)]^T$ , what is the right minimisation problem you need to solv maximum likelihood estimate of $\theta$ ? The problem is: $\min_{\alpha} \dots$ ?				unknown parameter $\theta$ , and a set problem you need to solve for a		
			(b)			
		y(k)				
19.			d on the covariance for any unbited as $M = \int_{yN} \nabla^2_{\theta} L(\theta_0, y_N) \cdot p(\theta_0, y_N)$			
	(a) $\square N/\theta^2$		(b) $\prod \int_{y_N} N\theta_0^{N-2} \exp[-\theta \sum_k y_k] dy_N$			
	(c) $\mathbf{x}$ $\theta_0^2/N$		(d)	$\sum_k y_k ] \mathrm{d} y_N \big)^{-1}$		
20.	The PDF of a random variable $x$ ments, $y(1) = 3$ , $y(2) = 6$ , and	Y is given by $p(y) = \frac{1}{2\sqrt{2\pi}} \exp y(3) = 12$ . What is the minimiz	$(-rac{1}{2}rac{\ y- heta\ _2^2}{4})$ , with unknown $ heta\in \theta^*$ of the negative log-likeliho	$\mathbb{R}$ . We obtained three measure-od function ?		
	(a) 4	(b) <b>x</b> 7	(c) 6	(d) 9		

Su	Surname: First Name:		Matriculatio	on number:		
Su	bject:	Programme:	Bachelor Master	Lehramt others	Signature:	
	Please fill in your name ab	oove and tick e	exactly ONE box for the	e right answer of each qu	uestion below.	
1.	Please give the ODE of a li $Ax + Bu$	inear time inva	ariant (LTI) system, wit	h state vector $x$ and inpu	at vector $u$ . $\dot{x} = \dots$	
2.	Please identify the most g $n = \max(n_a, n_b). G(z) =$		r function that still is	a Auto Regressive Mode	lel with Exogenous Inputs (ARX) wh	ere
	(a) $ \frac{b_0 z^n + b_1 z^{n-1} + \ldots + b_n}{a_0 z^n} $	(b) <b>x</b>	$ \frac{b_0 z^n + b_1 z^{n-1} + \dots + b_n}{a_0 z^n + a_1 z^{n-1} + \dots + a_n} $			
3.	Suppose you are given the matrix $\Sigma_{\hat{\theta}}$ of your estimate $\Sigma_{\hat{\theta}} \succeq M^{-1}$		nation matrix $M$ of the	corresponding problem,	, what is the relation with the covarian	nce
4.	Give the name of the theoretic Cramer-Rao Inequality	em that provid	les us with the above re	esult.		
5.	Which of the following mo	odels is time in	nvariant?			
	(a) $\dot{y}(t) = 5u(t) + t$	(b) <u>x</u>	$] \dot{y}(t) = \sqrt{u(t)}$		(d)	
6.	By which of the following	formulas is the	e joint distribution for	N independent measuren	ments $y_N \in \mathbb{R}^N$ given? $p(y_N \theta) = \dots$	
	(a) $\prod \int_{y_N} p(y \theta) \ dy$	(b)	$] \sum_{i=0}^{N} p(y(i) \theta)$		$(\mathbf{d})^2$ $\mathbf{x} \prod_{i=0}^N p(y(i) \theta)$	
7.	Which of the following sta	tements about	Maximum A Posterior	i (MAP) estimation is no	ot true	
	(a) MAP is a generali	ization of ML		(b) $\square$ MAP requires a-priori knowledge on $\theta$		
	(c) $\hat{\theta}_{MAP} = \arg \min$	$u_{\theta \in \mathbb{R}}[-\log(p(y))]$	$g_N \theta)) - \log(p(\theta))]$	(d) X MAP assumes	es a linear model	
8.	Which of the following mo	odel equations	describes a FIR system	with input $\boldsymbol{u}$ and output	$t y? y(k+1) = \dots$	
	(a) $u(k) + \sin(k \cdot \pi)$	(b) <u>x</u>	$ ] u(k) - 5 \cdot u(k-1) $	(c) $u(k) \cdot y(k)$		
9.	Which of the following dy	namic models	with inputs $u(t)$ and or	utputs $y(t)$ is <b>NEITHER</b>	R linear NOR affine.	
	(a) $\mathbf{x}\dot{y}(t) = \sqrt{t \cdot u(t)}$	(b)	$]\dot{y}(t) + \sin(t) = u(t)$		t (d) $u(t) = u(t) + 2$	
10.	the phone breaks when it i	is dropped. We ed 100 smartpl	e assume that the phor hones and obtained 42	e thrown onto the groun broken smartphones. Wh	e to know the unknown probability $\theta$ to either breaks or has no damage. In hat is the negative log likelihood funct	an
	(a) $\boxed{58 \log \theta + 42 \log(\theta)}$	$(1-\theta)$			$58\log(1-\theta)$	
	(c)	$g(58(1-\theta))$		(d) $\log(58\theta) + \log(58\theta)$	$\log(42(1-\theta))$	

	Given the probability density function of the exponential distribution, $p_X(x) = \theta e^{-\theta x}$ , with an unknown parameter $\theta$ , and a set of independent measurements $y_N = [y(1), y(2), \dots, y(N)]^T$ , what is the right minimisation problem you need to solve for a maximum likelihood estimate of $\theta$ ? The problem is: $\min_{\theta} \dots$ ?				
	(a) $\mathbf{x} - N\log(\theta) + \theta \sum_{k=1}^{N} y_k$	y(k)	(b) $\ y(k) - \theta e^{-\theta}\ _2^2$		
			(d)		
			d on the covariance for any unbited as $M = \int_{yN} \nabla^2_{\theta} L(\theta_0, y_N) \cdot p($		
	(a) $\prod \left( \int_{y_N} N\theta^{N-2} \exp[-\theta \sum_{x_i} dx_i] \right)$	$\sum_{k} y_{k} ] \mathrm{d} y_{N} \Big)^{-1}$	(b) $\prod N/\theta^2$		
	(c) $\mathbf{x}$ $\theta_0^2/N$		(d) $\prod \int_{y_N} N\theta_0^{N-2} \exp[-\theta \sum$	$\sum_k y_k ] \mathrm{d} y_N$	
		ation problems is solved at each	the linear model $y_N = \Phi \theta$ , when the iteration step of the RLS algo)		
	(a) $\ \theta - \hat{\theta}(N)\ _{2}^{2} + \ y(N - \hat{\theta}(N))\ _{2}^{2}$	$(+1) - \varphi(N+1)^{T}\theta\ _2^2$	(b) $\ y_{N+1} - \Phi_{N+1} \cdot \theta\ _2^2$		
	(c) $\ y_N - \Phi_N \cdot \theta\ _{Q_N}^2$		(d) $\ \theta - \hat{\theta}(N)\ _{Q_N}^2 + \ y(n)\ _{Q_N}^2$	$N) - \varphi(N)^{T}\theta\ _2^2$	
14.	Identify most general transfer fu	nction that still is a Finite Impul	lse Response (FIR) model with n	$g = \max(n_a, n_b). G(z) = \dots$	
	(a) $\frac{b_0 z^n + b_1 z^{n-1} + \dots + b_n}{a_0 z^n + a_1 z^{n-1} + \dots + a_n}$	(b) $X \frac{b_0 z^n + b_1 z^{n-1} + \dots + b_n}{a_0 z^n}$			
			system and can be modeled by ould you use to estimate the para		
	(a) Recursive Least Square	s (RLS)	(b) X Maximum a Posteriori	Estimation (MAP)	
	(c) Linear Least Squares (	LLS)	(d) Weighted Least Squares (WLS)		
		nms could you use to estimate th	be approximated by a model that the parameters $\theta$ of this linear mode to flow of measurement data?		
	(a) WLS	(b) MAP	(c) X RLS	(d) LLS	
		en as $y_N = \Phi_N \theta + \epsilon_N$ with $\epsilon_N$	on of the covariance of the esting $V \sim \mathcal{N}(0, \Sigma_{\epsilon}),  Q_N = \Phi_N^{\top} \Phi_N  \text{and}  V \in \Sigma_{\hat{\theta}} \approx \dots$		
	(a) $\mathbf{X}$ $Q_N^{-1}$	(b)	(c) $\square \nabla^2_{\theta} L(\theta, y_N)$	$(d) \ \square \ \Phi_N^+ \Sigma_{\epsilon_N} \Phi_N^{+  \top}$	
	In $L_2$ estimation the measureme compared to $L_1$ estimation.	nt errors are assumed to follow	a distribution and it is genera	lly speaking more to outliers	
	(a) Laplace, robust	(b) Gaussian, robust	(c) X Gaussian, sensitive	(d) Laplace, sensitive	
19.	Which of the following models w	with input $u(k)$ and output $y(k)$	is <b>NOT</b> linear-in-the-parameters	w.r.t. $\theta \in \mathbb{R}^2$ ?	
	(a) $u$ $u(k) = \theta_1 \sqrt{u(k)} + \theta_2 u(k)$		(b)		
	(c) $\mathbf{x}$ $y(k) = \theta_1 \exp(\theta_2 u(k))$		(d) $\square y(k) = \theta_1 u(k)^2 + \theta_2 \epsilon$	- ( ( ) / )	
20.	The PDF of a random variable Y	is given by $p(y) = \frac{1}{2\sqrt{2\pi}} \exp(-\frac{1}{2\sqrt{2\pi}} \exp(-\frac{1}{22$	$(-rac{1}{2}rac{\ y- heta\ _2^2}{4})$ , with unknown $ heta \in$	$\mathbb{R}.$ We obtained three measure-	
			ter $\theta^*$ of the negative log-likeliho		
	(a) 9	(b) 4	(c) 6	(d) x 7	